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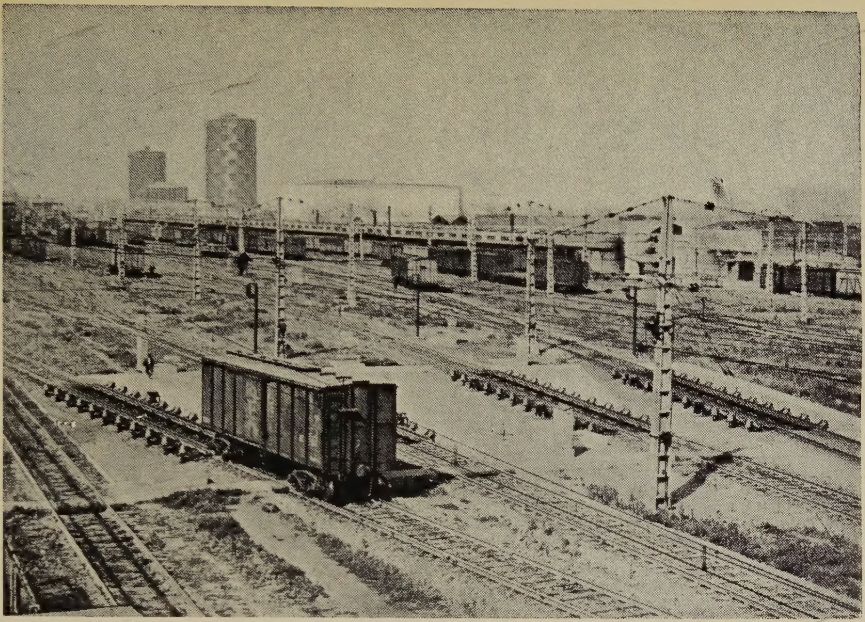
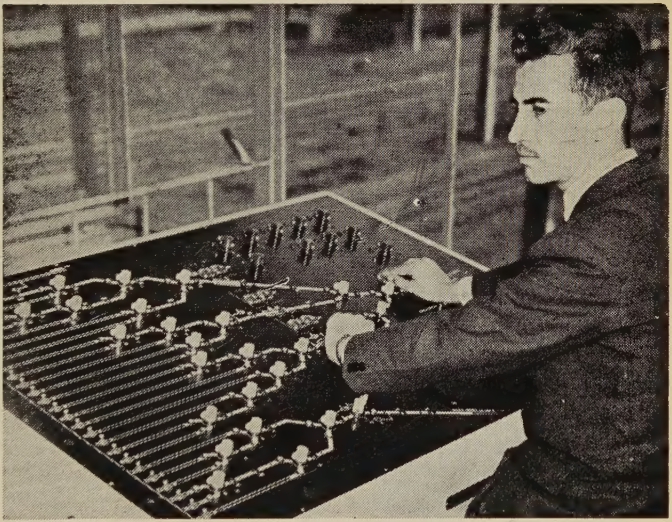
Monthly Bulletin of the International Railway Congress Association

(English Edition)

ALAMEIDA HUMP YARD, CHILE





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OF THE

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(ENGLISH EDITION)

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Bulletin of the International Railway Congress Association

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Vol. XXXVII. — No. 7. July 1960.

BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
ASSOCIATION
(ENGLISH EDITION)

[625 .251]

The problems arising when braking at present day speeds,

by Josip ŠVAGEL,

Engineer, Director of the Railway Institute of the Jugoslavian Railways.

The basic law of braking can be written mathematically in the form :

$$P_{\varphi} \leq N_{\mu}$$

wherein :

P is the force applied to the brake blocks in kg (*);

N is the weight on the rails of the braked wheel in kg;

φ is the coefficient of friction of the brake blocks;

μ is the coefficient of adhesion of the wheel on the rail,

and can be stated in the following terms : The brake power ought to be less or at most equal to the holding force permitted by the adhesion of the wheel on the rail.

In principle, the braking can be obtained in two clearly different manners :

— in the case in which P_{φ} is less than N_{μ}, the wheels roll along the rail;

— in the case in which P_{φ} is greater than N_{μ}, the wheels slide along the rails.

The limit between these two methods of braking is represented by the « limit of rolling » of the wheels.

The coefficient of adhesion μ varies very little as a function of the speed of rolling of the wheels. In practice, a constant value of about 0.17 can be accepted. On the other hand, its value varies appreciably according to the state of the rails; this value is low for slippery rails (greasy, damp, icy, with leaves, etc.); it is normal and about the same for dry or completely wet rails, and finally increases when the rails are sanded.

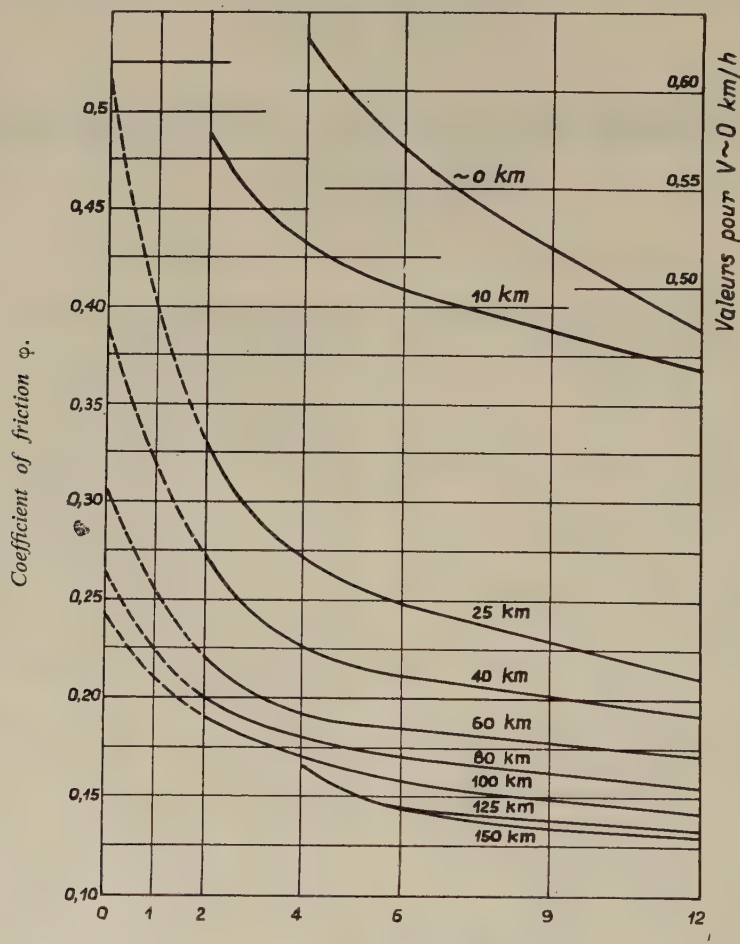
The wheels having been locked (it is then they slide on the rails) at the point of contact of the wheel with the rail sliding friction is set up, its value being $N.\mu\varsigma$. The values of $\mu\varsigma$, the coefficient of friction, are much smaller than those of μ, the coefficient of adhesion (about 35 %).

In train working, braking with the wheels locked is not acceptable as the stopping distance then becomes much longer (as a result of the lower value of the coefficient $\mu\varsigma$). Furthermore, at the continued point of contact with the rail, the tyres wear and flats which make the wheels unserviceable are formed.

(*) Unless explicitely indicated to the contrary, P in this article indicates in all cases the maximum force.

On the other hand, φ the coefficient of friction of the brake blocks varies very much. Above all it depends upon the pressure on the brake blocks; it is proportionally smaller as the pressure is higher. Moreover, it depends upon the quality of the cast iron of which the blocks are made, upon the degree of finish of the surfaces in contact, and on other factors.

Based on the tests made by METZKOW before the war at the Grünewald testing station, near Berlin, diagram No. 1 shows the variations in the coefficient of friction as a function of the principal factor upon which it depends, i.e. the pressure at the brake blocks.



Specific pressure on the brake blocks (kg/cm²).

Fig. 1. — Values of the coefficient of friction of brake blocks φ.

N. B. — Valeurs pour V ~ 0 km/h = values for V ~ 0 km/h.

The design of the brake allows most of the factors affecting the coefficient of

friction φ of the brake blocks to be taken into account. The influence of the speed of rotation of the wheels, on this coefficient, however, makes it very difficult to apply the fundamental law of braking even though so simple in expression. The examination of the most characteristic cases of braking shown on diagram No. 2 illustrates these difficulties.

been used to the highest degree, but for high speeds does not give sufficiently satisfactory stopping distances.

Case No. 3. — At the moment of stopping the braking force $P_\varphi < N_\mu$. The increase in the value of the coefficient of friction of the brake blocks φ is not, even at the moment of coming to rest,

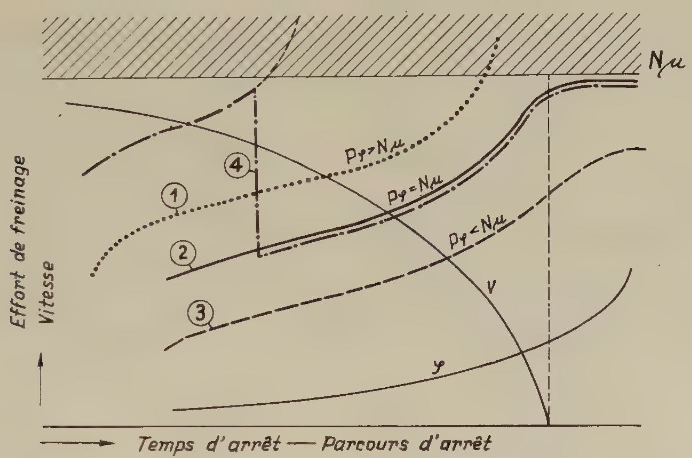


Fig. 2. — Different cases of braking as a function of the braking effort.

N. B. — Effort de freinage = braking effort. — Vitesse = speed. — Temps d'arrêt - Parcours d'arrêt = stopping time - stopping distance.

high enough for the curve to reach the « limit of rolling ». This signifies that the brake power has not been utilised sufficiently; thus the stopping distance has been lengthened.

Case No. 1. — Before coming to rest, the braking force is $P_\varphi > N_\mu$. When at low speeds the value of the coefficient φ increases, the curve of the braking force passes into the zone in which the wheels are skidded, and this before the speed falls to zero.

Case No. 2. — At the moment of stopping, the braking force $P_\varphi = N_\mu$. Owing to the increase in the value of the coefficient of friction φ, the curve of the braking force reaches « the limit of rolling » just at the moment of coming to rest. In this way, the holding force has

Combined cases :

The braking is done by the force on the blocks capable of skidding the wheels at reduced speed (case No. 1). A little before the moment when there is a risk of picking up the wheel, the force is reduced to the curve of the optimum braking, according to which the braking takes place until

stationary. This case gives the shortest stopping distance.

The combination considered above is that most frequently adopted nowadays. Naturally, there can be other combinations, possibly even more favourable, but which would bring in other difficulties and in particular from the constructional aspects.

The variation in the force at the brake blocks are obtained by a device known as the « pressure regulator ». This fitting reduces the force on the blocks by letting air out of the brake cylinder *at the moment the risk of skidding arises* and this as a rule at a predetermined speed.

This definition has been given here to underline the difference between the device in question and the anti-slip equipments which have the object of preventing the slipping of the wheels from persisting. These latter let air escape from the brake cylinder *just at the beginning of the slipping*. The working of the pressure regulator is as a rule by the centrifugal regulator whereas the anti-slip equipments are brought into action by the force set up by the momentary slipping of the wheels.

Under average conditions of the specific force acting on the block and of the quality of the cast iron, the most favourable moderate braking is obtained for a force acting on the brake block P the maximum value of which can reach 0.85 N. The manufacturers only admit this maximum value reluctantly seeing that in certain cases with double blocks, the wheels will not slip even if P equals N. Such a design of brake usually has the braked weight N equal to the weight on the rail so that : $B = N$ (The braked weight represents the notion of the braking power. It indicates the weight on the rail that the brake is able to stop on a given distance under the conditions for which the braking rules prescribed a value of 100 %). In this case, the percentage of brake weight, that is to say, the ratio between the brake weight and the weight on the rail is the following :

$$\frac{B}{N} \cdot 100 = 100 \text{ \%}.$$

A vehicle fitted with such a brake can when taken by itself run at speeds high enough for goods trains. For the speeds now envisaged for passenger trains, such a brake does not give satisfactory results. In fact, for these high speeds, each vehicle considered individually has to satisfy the braking requirements seeing that for these speeds the excess of brake weight of one vehicle cannot be used to make good the value of the brake weight of another. Moreover, the percentage of the brake weight should be much higher than 100 %. Such a brake weight can only be obtained by increasing the ratio of the power at the blocks and the weight on the rails of the vehicle, which is the source of all increase of brake weight. We are obliged consequently to turn to the method of braking which for lower speeds falls within the zone in which the wheels slip. To avoid this, it becomes necessary to provide a brake for combined braking starting with a high power at the blocks which before reaching the « limit of rolling » has to be reduced to the most favourable moderated brake application (0.85 N).

Božić, the well known Jugoslavian compressed air brake manufacturer, has been the first to occupy himself with this problem with a view to arriving at its practical solution (fig. 3). He has intro-

duced in his distributor specially adapted for this purpose, a small lever with two arms $g - d$, the middle bearing point of which m, carried in a roller bearing, can be moved from outside so that during the braking the ratio of the arms changes. This movement is obtained by connecting the mobile point of support to the sleeve of a centrifugal regulator (this is the first application of a centrifugal regulator with this object in view !) driven by belts from an axle of a vehicle.

The arm g of the lever bears on the main piston, subjected to the air pressure of the train pipe and of the control reservoir, whilst the other arm d bears on the balancing piston, subjected to the pressure in the brake cylinder. When the weights of the regulator are fully apart, which corresponds to the maximum speed of the vehicle, the ratio of the arms $\frac{gm}{md}$ has a value such that the difference between the two pressures acting on the main piston are in balance with the maximum force on the balancing piston, i.e. to the maximum pressure in the brake cylinder.

As soon as the weights of the regulator, through the speed falling, begin to approach one another, the arm on the side of the balancing piston lengthens, whilst the arm on the main piston side shortens to the same extent. The moment of the force on the side of the balancing piston overrides that of the main piston. In descending the main piston opens the exhaust valve which begins to discharge air from the brake cylinder.

During a full application, the air is discharged from the brake cylinder without interruption until its pressure reaches the value corresponding to the position of the weights in their closest position, i.e. at the stage of reduced force. Otherwise, the exhaust of the air is interrupted according to the position of the weights of the regulator which corresponds to the speed at which the braking occurs.

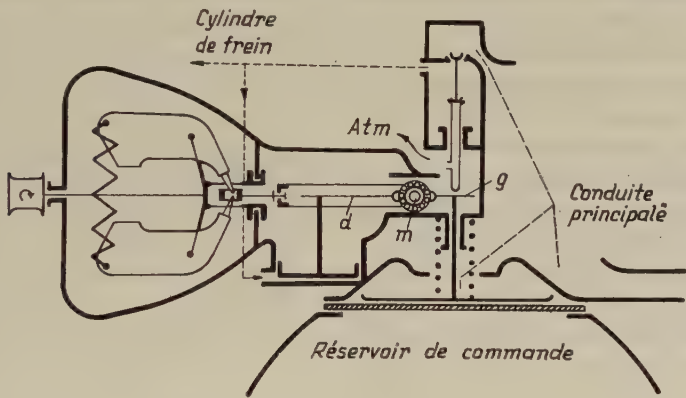


Fig. 3. — Božić centrifugal type pressure regulator.

N. B. — Cylindre de frein = brake cylinder. — Atm = atmosphere. — Conduite principale = train pipe. — Réservoir de commande = control reservoir.

In order to prevent passing the « limit of rolling », Božić lets the air escape from the brake cylinder starting from the maximum speed by a suitable choice of characteristic of the regulator spring, and this following a line which in turn depends on the characteristic of the spring. As it would be possible, based on the coefficient of friction φ to determine for each speed the force P at the brake blocks, it would also be possible by the characteristic design of the regulator to obtain a curve of the force at the brake blocks which would develop in the zone of rolling of the wheel more or less parallel with the limit of rolling. This proposal has been subjected to test. At that time the moment had not yet come for this conception to result in absolutely satisfactory designs.

As can be seen, the pressure regulator, according to Božić, was linked to the construction of the distributor. The builders who studied the question after him

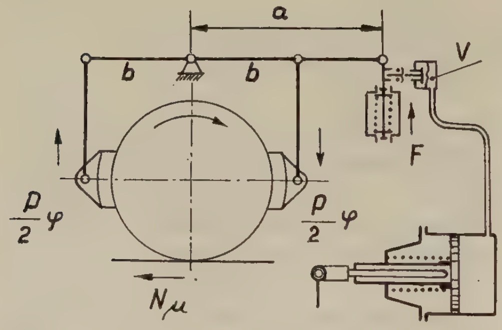


Fig. 4. — « Knorr », type mechanical pressure regulator.

proposed a regulator able to work with any type of distributor. The first of this type of apparatus was the « Knorr » pressure regulator (fig. 4). Actually it is very simple and is based on a working principle equally simple. The brake blocks fitted on each side of the wheels of the vehicle are suspended from a balancing lever, and one of its arms which is extended bears at its end on a powerful spring. This extension acts on the exhaust valve which communicates with the brake cylinder.

Based on the maximum force, calculated as a function of the braking percentage adopted, the force with which the wheel takes with it the brake blocks is calculated for each speed.

The moment of this force relatively to the point of support of the balancing lever is opposed by the moment of the resistance to compression of the spring. When the moment of the force overcomes that of the resistance, the balancing lever rocks down and opens the exhaust valve by which the air of the brake cylinder escapes. The condition required for the valve to open is expressed by the formula :

$$2 \cdot \frac{P}{2} \cdot \varphi \cdot b = F \cdot a.$$

The risk of the wheels slipping occurs just before reaching the « limit of rolling », which according to the fundamental formula of braking occurs at the moment when the following relation is satisfied :

$$2 \cdot \frac{P}{2} \cdot \varphi = N_\mu,$$

whence :

$$N \cdot \mu b = F \cdot a,$$

which gives :

$$F = N \cdot \mu \frac{b}{a}.$$

In order to make certain slipping does not occur, which slipping can be due to a

certain inertia in working of the fittings, in the calculations the coefficient of adhesion has been reduced by 10 %, i.e. to 0.135. Consequently the resistance to compression of the spring has been given the following value :

$$F = 0.135\ N \frac{b}{a}.$$

The speed at which the regulator of pressure comes into action is determined by the coefficient of friction of the brake blocks, which multiplied by the force at the blocks equals $\mu N \cdot \frac{b}{a}$. If on the other hand, the regulator of pressure is required to act at a given speed, it is this speed which determine *the brake* percentage of weight.

The instant at which the regulator comes into action is not sufficiently precise. It is a function of the value of several coefficients and especially of the value of the coefficient of friction of the brake blocks, which is subject to the influence of many transitory circumstances.

As soon as the regulator of pressure comes into action, the feed of air to the brake cylinder by the distributor acting independently of the regulator has to be prevented by a special fitting.

The inertia in working of the layout prevents the emptying of the brake cylinder from being stopped at the moment equilibrium is established; it occurs at a lower pressure, the value of which is rather indeterminable. The result as a rule is that the fitting which prevents the auxiliary reservoir from being discharged maintains in the cylinder until the stop a pressure fixed beforehand (regime at reduced power). The use of this arrangement in service has been given up because of its lack of sufficient precision in operation. Another notable defect in this device is the disparity in functioning in the two directions of running, when the force on the brake blocks is not equally divided between the wheels.

In addition, through defective erection, the resistance of the spring can be badly adjusted. If the strength of the spring is too great, the regulator of pressure can act too late and this can pick up the wheels. If the strength of the spring is too low, the regulator comes into action too soon. Under such circumstances, it is preferable not to have a regulator.

In the subsequent development, a design of regulator was brought out which had two determined stages of force on the blocks : a high force at the beginning of the brake application when the brake is applied at a speed above that predetermined; and a reduced force as soon as the speed has fallen below this value. The high force is maintained in the interval in which the value of the coefficient of friction of the brake block is low, whereas the reduced force is obtained at the moment at which the risk of passing the « limit of rolling » arises.

For the speed M km/h at which the change of force takes place, the value 60 to 50 km/h has been adopted. Since some years, however, for vehicles running at high speed the speed selected has been between 70 and 60 km/h, having taken into account the maximum speed allowed on down grades in order to avoid when regulating it the force becoming reduced. This reduction would provoke variations of speed and reactions which could not be accepted.

The change to reduced force is assured by a centrifugal regulator by means of a mechanical or electrical drive. One of the axles of the vehicle transmits the movement to the regulator. This regulator is fitted directly to the end of the axle journal or mounted separately and driven through gearing.

The reduction of the braking force is obtained through a mechanical transmission, for example in the case of the « Knorr » regulator (fig. 5). It can be applied to every type of distributor D. The air from the distributor does not feed directly to the brake cylinder, but first of all passes into the small reservoir *r*, and thence to the pressure changer S. The pressure changer has two horizontal diaphragms suspended from the body by membranes. The diaphragm K_2 separates the lower space into which the air from the small reservoir *r* flows from the top space which by the regulator valve can become in communication either with the supplementary reservoir or with the atmosphere. The upper diaphragm consists of the assembly K_1 - K_3 the inside of which is under atmospheric pressure. The space below the lower diaphragm is in communication with the small reservoir *r*, whereas the space above the upper diaphragm is connected directly with the brake cylinder. The pressure in the brake cylinder depends upon the pressure of the air in the small reservoir *r*, and also upon the action of the centrifugal regulator.

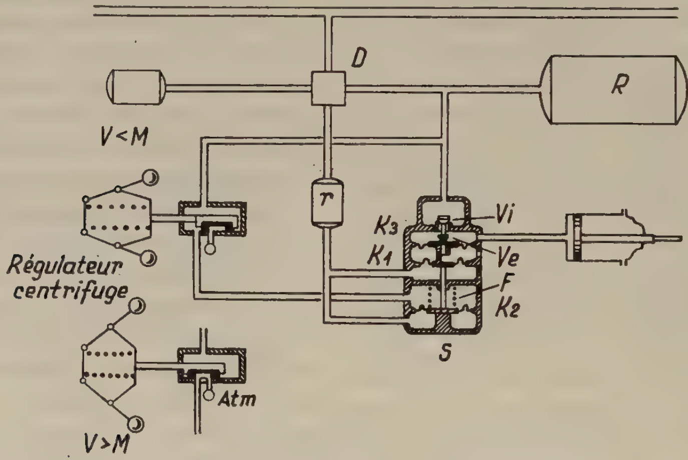


Fig. 5. — « Knorr » type centrifugal pressure regulator.

N. B. — Régulateur centrifuge = centrifugal regulator.

At the start of braking, the air from the distributor starts to fill the small reservoir *r* and the space under the diaphragms K_2 and K_1. The pressure lifts the diaphragm K_2 as well as the assembly K_1 - K_3. Through the upward movement of the assembly K_1 - K_3 the exhaust valve *Ve* closes whilst the admission valve *Vi* opens. In this way, the air from reservoir R passes to the brake cylinder. If the braking is from a high speed (about M km/h) the regulator maintains the valve

in the position wherein, with its weights out, the exhaust opening communicates with the space above the diaphragm K_2. The passage of air from the reservoir R to the brake cylinder continues until the moment at which the pressure in the brake cylinder has a value double that in the small reservoir *r*, as the force above K_3 exceeds that below the diaphragms K_1 and K_2.

When, during braking, the speed of the train falls below M km/h or when braking starts at such a speed, the weights of the regulator come inwards to such an extent that the valve of the regulator uncovers the orifice of the passage between the reservoir R and the space above the diaphragm K_2. The pressure always above that existing in the small reservoir, to which is to be added the action of the spring F, pushes the diaphragm K_2 into its lower position. At this moment only the pressure in *r* acts from below on the diaphragm K_1 whereas from above there acts a pressure which is twice as high as that of the brake cylinder. Evidently the assembly K_1 - K_3 descends at once to its lowest position in which the exhaust orifice to atmosphere V*e* is open. Thereafter the air escapes from the brake cylinder until the moment when its pressure becomes equal to that in the small reservoir *r*, i.e. half the earlier value corresponding to the regime of high speeds. Due to this, the force on the brake blocks is reduced by a half and the skidding of the wheels at less high speeds is prevented. The variations moreover can take place within in two different ranges, set by the centrifugal regulator. If the weights of the regulator are apart for speeds above M km/h, the pressure in the brake cylinder is set at a predetermined value, the maximum being four atmospheres. If contrariwise, the weights of the regulator are in one of the positions corresponding to the speeds below M km/h, the pressure in the brake cylinder can reach half the previously mentioned value.

The mechanical transmission from the drive of the centrifugal regulator to the pressure variator was found to be a weak point of the arrangement. Naturally, when perfecting these designs, electric power was adopted for transmitting the drive from the centrifugal regulator to the pressure variator. All vehicles running at high speeds are fitted with electric lighting. Consequently, the same current can be used for altering the braking regimes, the more so as only an insignificant quantity of current is needed. This current is only required for the high stage of braking. In case of failure of current or of its equipment, the braking even at high speeds still is effected in complete safety at the lower braking regime. This might, it is true, give rise to an increase in the stopping distance if it were a case of an isolated vehicle, but in the real case of a complete train, the incidence of the reduction of the braking force is almost of no importance and does not bring with it any serious danger.

The « Oerlikon » Company's design (fig. 6) includes a centrifugal regulator secured to the end face of the axle journal inside the axlebox. The design of the pressure variator differs somewhat from the one described above. The hollow spindle *d* carries three pistons. The pistons separate by means of turned up diaphragms in compression, four spaces :

the space below the lower piston K_2 communicates with the distributor parts regulating the admission of air to the brake cylinder when braking and its cylinder by means of the hollow spindle once it comes away from the valve V_1. The air in the space between piston K_1 and the upper piston K_3 can be either opened

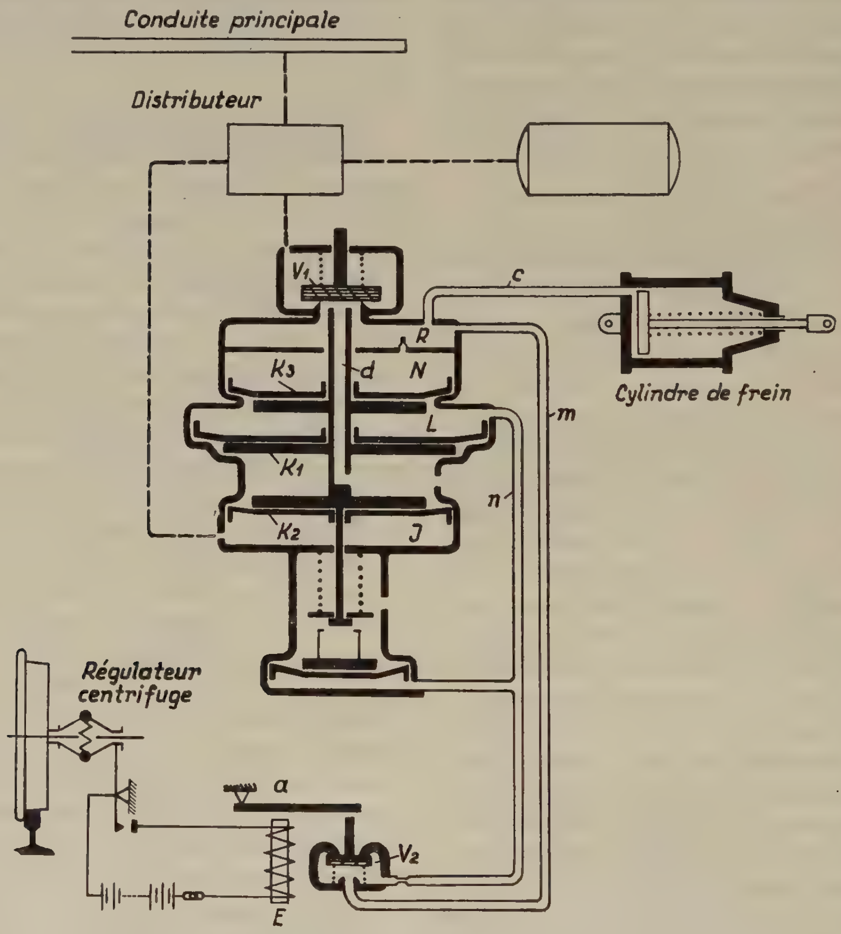


Fig. 6. — « Oerlikon » type centrifugal pressure regulator.

N. B. — Conduite principale = train pipe. — Distributeur = distributor. — Cylindre de frein = brake cylinder. — Régulateur centrifuge. = centrifugal regulator.

escape when releasing. The space between this piston and the piston K_1 above it, is always open to atmosphere. This space is put into communication with the brake to the air from the brake cylinder by the passages *n* and *m*, or exhausted to the atmosphere by the passage *n* and the open valve V_2. The space above the

piston K_3 is in communication with the brake cylinder by a nozzle which like that in passage *n* slows down the passage of the air from the brake cylinder to the spaces L and N.

If the brake be applied at a speed above M km/h the weights of the regulator fly out to such an extent that they cause the electrical circuit to be closed; the electromagnetic relay E, being excited, attracts the armature *a*, which by its right hand end presses the valve V_2 onto its lower seat so closing the passage *m*. The distributor lets the air for the application flow into the space J below the lower piston. The air raises the mobile portion into its upper position so that the hollow spindle comes up to the valve V_1 and lifts it. In this way, air passes from the auxiliary reservoir to the space R and then by the passage *c* to the brake cylinder. From the space R, the air flows through the calibrated nozzle to the space N but at a reduced rate. The filling of this space continues until the moment the pressure in it exceeds a little that in the space J. The hollow spindle then falls and causes the valve V_1 to reseat, without coming off however from the seating in the end of the hollow spindle. This state of affairs (regime at high speed) is maintained until the speed of the vehicle reaches the limiting speed. The weights of the regulator then come in and cut off the current; the armature rises and lifts the valve V_2. The spring lifts the valve and holds it onto its upper seat. At the same time, the communication between the channels *m* and *n* is opened and the air which is in communication with the brake cylinder fills the space L. The pressure below the upper piston becomes in equilibrium with that above it. The pressure on the intermediate piston, the surface of which is double that of the lower piston, displaces the mobile assembly down to its lowest position. The hollow spindle then comes away from the valve V_1, and lets the air escape to atmosphere by its proper opening. The air of the brake cylinder like that in the spaces R, N and L escapes to atmosphere until the pressure drops to half that of the initial pressure. The force acting from below on position K_2 overcomes the weakened pressure acting from above on a surface twice greater than that of the piston K_1. Due to this the mobile unit rises until the hollow spindle comes again into contact with the valve V_1 without lifting it off its seat. In the brake cylinder as has been said already, the pressure of the air is now half the initial pressure and holds this value until the vehicle stops (regime at reduced power).

The condition of the regular functioning of the two stage antislip devices in question is that at the speed M or at the moment of stopping, the relation below is satisfied:

$$P_v \cdot \varphi_M = P_n \cdot \varphi_n \leq N \cdot \mu,$$

in which :

- P_v is the force at the brake blocks at the high power regime;
- P_n is the force at the brake blocks at the reduced power regime;
- φ_M is the coefficient of friction of the brake blocks at a speed of M km/h;
- φ_n is the coefficient of friction of the brake blocks at the moment of stopping;
- N and μ are the values analogous to those used above.

As a general rule P_v is made equal to $2 P_n$ whilst taking into account that in practice the values of the coefficients of friction are linked together in the following relation : $\varphi_n \simeq 2 \varphi_M$.

has cells partially filled with mercury. Two poles of the circuit of the accumulator battery project into each cell.

The pressure variator contains three spaces : the upper space A, which is in

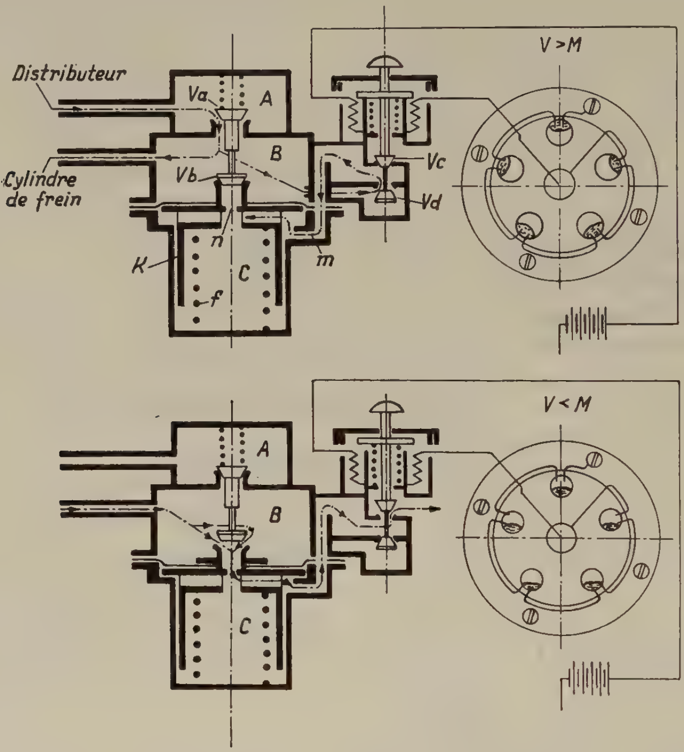


Fig. 7. — « F.S. » mercury type regulator.

N. B. — Distributeur = distributor. — Cylindre de frein = brake cylinder.

Obviously the fundamental condition for the reduced power regime ($P_n \leq 0.75$ — 0.85 N) is complied with therein.

The two stage regulator, as designed by the Italian State Railways (fig. 7) is particularly interesting. The mechanical centrifugal regulator is not used in it but in its place a mercury regulator fitted at the end of an axle journal. The regulator

communication with the distributor; below it, is the space B which communicates with the brake cylinder; and the buttom space C separated from B by a piston with membrane K, in which is a strong spring *f*.

The double valve V*a* - V*b* separates these three spaces, depending upon the condition of pressure of the air therein and the resistance of the spring *f*. To

the right, at the side of the variator is shown the valve V*e* - V*d* constantly held up by the spring. The double coil of the electromagnetic relay is wound round the valve and is excited by current from the battery. When the relay is excited the valve V*c* closes the space C from the atmosphere. When the relay is disexcited, the spring closes the valve V*d* and closes the communicating passage *m* between spaces B and C, and the valve V*c* being raised restores communication between space C and the atmosphere.

When the speed of the vehicle is above the predetermined speed M, the centrifugal force throws the mercury to the periphery of the cells. This causes the circuit to close and the electromagnet then attracts the double valve V*c* - V*d*, causing the valve V*c* to bear on its seat and lift the valve V*d*. In extending the spring lifts the piston K to its highest position at which the upper valve V*d* is open whereas the lower closes the communication between the spaces B and C. If the brakes are applied in such circumstances, the air from the distributor passes by V*a* into the brake cylinder. At the same time, the air passes by passage *m* from the middle space to that under the piston K. As the forces resulting from the pressure of the air above and below piston K are in equilibrium the double valve is maintained in its position solely by the action of the spring *f*.

When, as a result of the speed dropping, the centrifugal force is lessened, the mercury returns to the lowest part of the cells by the action of gravity. The electric circuit is broken and the electromagnet disexcited. The spring raises the valve V*c* and opens the lower space to atmosphere. At the same time the communication between the middle space and the lower space of the variator, which was open when the valve V*d* was open, is cut. The lower space empties itself instantaneously and the pressure of the air in the intermediate space overcomes the resistance of the spring *f*. The piston K falls to its lowest position and the valve V*b* comes off its seating. The spring above the valve V*a* applies this to its seat and closes the passage between the spaces A and B. The brake cylinder exhausts to atmosphere by the calibrated nozzle or cone. The air discharges until the moment the pressure of the air in the brake cylinder and in the space B falls to that determined by the resistance of the spring *f*. At this instant, the piston K lifts until the valve V*b* seats itself and prevents further discharge of the brake cylinder. In this way, the effort set up at the brake blocks is less than 0.85 N and any skidding of the wheels at lower speeds is avoided.

The distributor moreover can readily regulate the pressure in the brake cylinder during the two stages by means of the valve V*a* when lifted and by its own exhaust passage. As explained above the pressure regulators already described reduce the pressure in the brake cylinder before the wheels are skidded. The anti-slip devices, on the contrary, are brought into action by the momentary slipping of the wheels and that just at the moment it happens. The working of the anti-slip devices of older design is controlled by a centrifugal regulator. As a result of the sudden and rigid stopping of the rotating masses, however, the centrifugal regulator is subjected to excessive strains. In consequence, the most recent designs

incorporate an inert mass of annular form which comes to rest elastically. In this way, the above defect is removed. Of the existing devices of this class, we will now describe the « M » type of the Deutsche Bundesbahn.

In the axle box (and each axle has to be fitted) the carrying sleeve *g* is connected to the journal and carries a cylindrical flywheel *m*. The sleeve and flywheel are connected together by the vane K, which position, the exhaust valve properly speaking, V*e*, puts the cylinder into communication with the atmosphere, whereas in the lowest position communication is opened between the distributor and the brake cylinder.

The safety valve S carries at its upper end the conical valve V which bears on a rubber diaphragm. The coned valve like the safety valve have nozzles for the passage of the air. The compressed air

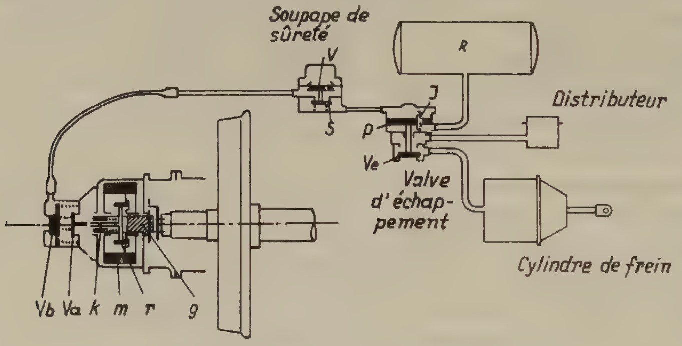


Fig. 8. — Type « M » anti-slip equipment.

N. B. — Soupape de sûreté = safety valve. — Distributeur = distributor. — Valve d'échappement = exhaust valve. — Cylindre de frein = brake cylinder.

has a horizontal spindle and a bar at right angles thereto carrying at its ends the rollers *r*. A spring presses the rollers against the inclined slides fitted to the flywheel. The axle box fitting is in communication by two retaining valves V*a* - V*b* with the safety valve and also with the exhaust valve. This latter communicates with the supplementary reservoir R, the distributor and the brake cylinder. The piston P of the exhaust valve embodies a slide-valve J consisting of two valves : when the piston is in its bottom position, the small nozzle alone is open; when it is in its upper position, the two nozzles are open. When the piston is in its upper

from reservoir R passes by the nozzles of the slide valve J then by the safety valve to the valve V*b* in the axle box and passing through the nozzle thereof applies the valve V*a* to its seat. In passing through the safety valve, the air passes by the nozzle of the coned valve into the space above the diaphragm.

When on applying the brake, the axle slips through too high pressure in the brake cylinder, the flywheel continues to turn and preceeds in its rotation the carrying sleeve. The wheels run up the full length of the inclined slides so that the extension moves on its axis and lifts the valve V*a*. The air above the valve escapes

at once and causes the valve V*b* to lift through which the pipe of the safety valve empties. The pressure above the diaphragm presses it downwards, the valve S opens and allows the air above the piston P to escape to atmosphere. The reservoir R pressure lifts the piston P, which opens in turn the valve V*e*, through which part of the air of the brake cylinder escapes to atmosphere and the wheel ceases to slip. The exhaust valve is opened only a moment as the nozzle in the upper piston immediately re-establishes the same pressure on both sides of the piston and the pressure from the distributor presses the exhaust valve onto its seat.

The safety valve makes certain the arrangement works in the event of leakage or fracture of the rubber pipe connecting it to the axle box. Then the space above the coned valve empties itself slowly by the nozzle and the spring finally forces the safety valve onto its seat. In this manner, the emptying of the supplementary reservoir is prevented, as it only empties to a small extent by the nozzle of the valve S and any leakage is made good immediately.

The device described above undoubtedly prevents any dangerous slipping of the wheels. Extra expenditure in fitting them is incurred and they add complication. The principal objection however to them is that their use involves serious risk as regards the stopping distance. Although according to their design the emptying of the brake cylinder lasts a very short time, the resulting reduction of power is indeterminate and often gives rise to an increase in the stopping distance at the high speeds of today.

This is why today the efficacity of these devices is queried and the Administrations find it difficult to decide to install them.

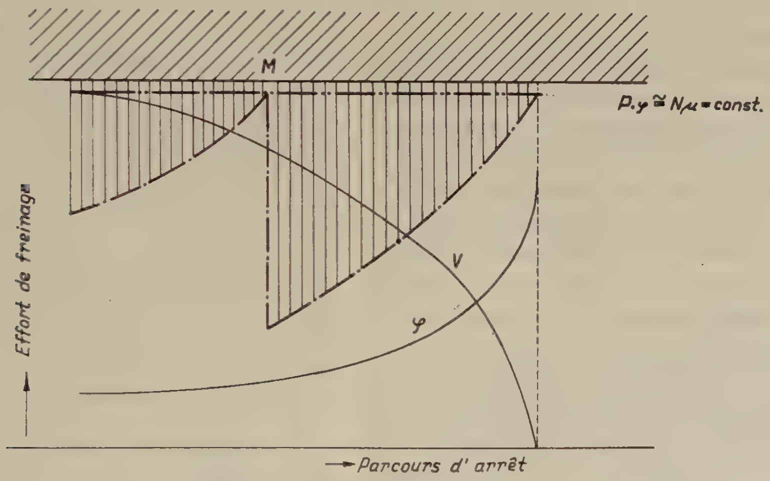


Fig. 9. — Braking diagram.

N. B. — Effort de freinage = brake force. — Parcours d'arrêt = stopping distance.

In the same way, the Sub-Commission of U.I.C. (I.R.U.) is divided in its opinions and shows a tendency to contest the advisability of adopting anti-slip devices. It appears to be preferable to place confidence in the single two stage brake in spite of the designed weakening of the brake at its own critical moment rather than to establish a brake the braking power of which is not definite enough.

Moreover, the tendency to achieve ever higher speeds imposes enquiry into new ways in braking technique. It is precisely thanks to more reliable and more effective brakes that such high speeds can be adopted in practice. Now, the two stage brake although without criticism from the point of view of the stability of the braking effect it assures, from the point of view of its effectiveness at the higher speeds leaves something to be desired. In fact, a glance at the diagram of the work done when braking shown in figure 9 is enough to see the low efficiency at which it acts. The hatched area of the diagram represents the braking effort lost for ever because the braking was not done up to the « limit of rolling », that is to say that the following conditions $P\varphi \simeq N\mu = \text{const.}$ was not fulfilled. It appears to be practically impossible during the short distance of the stop to adapt constantly the pressure at the brake blocks to the capricious variations of the coefficient φ.

In our opinion, moreover, the enquiries into materials for brake blocks of special composition with a coefficient of friction φ more constant have not been pursued as actively as they should have been. Has it been reasonable to limit oneself when applying any particular materials to special systems of brakes (drum and disc brakes) not capable of being applied on a large scale in the general working of railways ? The brake equipment makers have ceased, possibly without justification, to interest themselves in it after having abandoned the use of brake blocks applied to vehicle wheels by trying to resolve the problem by adopting the electromagnetic brake acting on the rails. Actually, the use of this precarious palliative is limited by particular conditions which only some special types of vehicles can satisfy.

The brake manufacturers in this way find themselves always confronted with the very important problem of seeking a brake of the simplest possible construction, guaranteeing the circulation of the trains even at the highest speeds of today, as well as those the future already leaves us to envisage.

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India Re-visited.

Some impressions of the 1959 I.R.C.A. Meeting and Post-Meeting Tour,

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Introduction.

Having spent a number of years seconded to the Great India Peninsular Railway before the war and having returned to India on transportation work during the war, I was particularly glad to attend the Enlarged Meeting of the Permanent Commission of the I.R.C.A. which was held in New Delhi in December 1959. I was also most fortunate in being invited to spend a week before the meeting in discussions and conferences on safety and other railway problems with the Chief Government Inspector of Railways, Officers of the Railway Board and of the Council of Scientific and Industrial Research.

This tour awakened many nostalgic memories and enabled me to compare the new conditions with the old. I came away greatly impressed by the remarkable progress made in recent years by the Indian Railways and by the high standards of efficiency which have been attained.

I travelled for hundreds of miles on these railways and met Indian railwaymen of every rank and grade from Mr. K. Mathur, Chairman of the Railway Board, and several of the Railway General Managers, to the drivers on whose engines I travelled for part of my journey. This paper is an attempt to give an account of a tour which to me was memorable and which I believe all I.R.C.A. delegates found most interesting and rewarding.

The Indian Government Railways.

Before giving my impressions of the tour, it might be desirable to state some facts about the Indian Government Railways as they are today — the largest in Asia and the fourth largest in the world. They cover some 34 600 route miles, of which 16 400 are broad (5 ft. 6 ins.) gauge, 15 500 are metre gauge and 2 700 are narrow gauge : there are some additional 445 miles of privately-managed light railways.

The system is divided into eight zonal railways, each under the charge of a General Manager, and each railway is divided into a number of divisions, each under a Divisional Superintendent who acts as an Area Manager. Control at the centre is exercised directly by the Minister of Railways who functions through the Railway Board, an expert executive and secretarial body with its

headquarters in New Delhi. Since the Minister is directly responsible to Parliament for the day to day working of the railway he has to answer many questions. For example, 1 818 questions were asked in the two Houses during the year 1957-58. The railway budget also occupied much Parliamentary time, being debated for five days in the Lok Sabha and for four days in the Rajya Sabha. In addition, it is the practice for the General Managers to be called to New Delhi each year to answer questions put to them by M.Ps.

During the year 1957-1958 some 1 400 million passengers and 113 million tons of freight were carried for a cost of approximately £198 millions and they produced a profit of £77 millions, of which £34 millions was appropriated to the Depreciation Reserve Fund.

Since « Partition » in 1947, there has been a remarkable increase in the traffic carried by the railways; in the 10 years since 1948-49 — the first complete year after independence — freight tonnage has increased by 61 % and passengers carried by 24 %. This rate of increase continues, and by March 1961, it is estimated that the railways will be able to carry 161 million tons of freight, an increase of 42 1/2 % since April 1958. Passenger-carrying facilities are not being expanded so rapidly, owing to limited resources, but even so the railways should be capable of handling within the same period 10 % more passengers on the broad gauge and 23 % more passengers on the metre gauge.

The First Five-Year Plan.

When India became independent in 1947 she inherited a railway system which had been overworked almost to breaking point under the stress of the last Great War, and one of the major tasks of the newly formed Indian Government was to rehabilitate and develop this fine but worn-out system to meet the growing economic needs of the country. They decided to follow the example set by other countries in formulating Five Year Plans covering development in every sphere. The first Plan was launched in April 1951, and for the railways it necessarily concentrated on the replacement of worn-out rolling stock and equipment and the rehabilitation of other physical assets. During the period April 1951 to March 1956 nearly 1 600 locomotives, 4 800 coach units and 61 000 wagons (in terms of 4-wheelers) were acquired. Some 430 miles of branch lines, which had been dismantled during the War, were restored, 380 miles of new lines were opened for traffic, and 7 000 miles of track were re-laid. The most important individual project was the Chittaranjan Locomotive Works which went into production during this period, and had turned out 348 locomotives by the end of it. The Integral Coach Factory at Perambur, near Madras, was also completed by the end of the period. The total cost of all these works, was £318 millions.

The Second Five-Year Plan.

The Second Five-Year Plan (April 1956-March 1961) is now in full swing. It was intended originally to allot £1 100 millions, but owing to the limited resources and the claims of other sectors of the community the allotment to Indian Railways was reduced to

£ 844 millions. Of this amount £ 280 millions will be found from the Railway Revenues, including £ 170 millions from the Depreciation Fund, and the remainder from the Government's General Funds. It is estimated that with this allocation the Railways will be able to achieve the target quoted in an earlier paragraph. The Development Programme includes the following major works :

a) the construction of about 842 route miles of new railways mainly to serve the requirements of the coal and steel industries;

b) the doubling of some 1 600 route miles of track;

c) the conversion of 265 route miles of metre gauge into broad gauge;

d) the electrification of 1 343 route miles of existing lines where density of traffic is such that steam traction cannot move all the traffic offering (it is expected that 800 miles will be completed in the period and preliminary work begun on the balance);

e) the relaying of 8 000 miles of track;

f) the procurement of 2 364 locomotives, 11 575 coaching stock units and 107 250 wagons (in terms of 4-wheelers).

I.R.C.A. Meeting.

On the morning of Monday 7th December, the opening ceremony of the Enlarged Meeting of the Permanent Commission of the I.R.C.A. was held in the Vigyan Bhavan, a very fine modern building especially designed and equipped for the holding of International Conferences. The meeting was opened by Mr. JAGJIVAN RAM, the Minister of Railways, in the presence of M. DE VOS, the President of the I.R.C.A., the delegates and a large number of Indian Railway Officers. Afterwards the delegates were presented to the Minister and met the chairman, Mr. MATHUR, and Members of the Indian Railway Board, some of the General Managers, and many other Railway officers.

Under the Presidency of Mr. A. BROUCKAERT, of the S.N.C.B., we discussed the question « Problems met in the design of multi-current rolling stock. Existing types : experimental results : future developments ». Mr. J. J. JONKER, of the Netherlands Railway, was the reporter for the English speaking countries and also the special reporter, and Mr. M. K. VON MEYENBURG, of the Swiss Federal Railways, was the reporter for the French speaking countries. The discussions were continued on Tuesday, when the examination of the summaries was concluded. Later that day, Mr. S. B. WARDER, Chief Electrical Engineer, British Transport Commission, gave a very interesting and informative lecture on the British Railways high voltage electrified system. He had previously toured Indian Railway electrification works in Bombay and Calcutta and had lectured to Indian Railway officers at both these important centres. He left for the United Kingdom on the following morning.

On Monday evening the delegates attended a reception given by the Railway Board at Baroda House, followed by a dinner given by the Minister of Railways at Hyderabad House. On

Tuesday evening the I.R.C.A. banquet was held at the Ashoka Hotel, a fine modern building in the Embassy sector of the city. The Minister of Railways was the principal guest and the Chairman and other members and officers of the Indian Railway Board were also present. The closing session of the I.R.C.A. Meeting was held on Wednesday morning and that evening we witnessed the wonderful welcome given to President EISENHOWER, whose journey from Palam Airport to the Rashtrapati Bhavan, the President of India's residence, was much delayed by the huge enthusiastic crowds who swarmed the streets and held up his car in Connaught Circus, a focal point in New Delhi which had been brilliantly illuminated for the occasion.

The I.R.C.A. Post Meeting Tour.

On Thursday morning, 10th December, the delegates left New Delhi by special train for a tour of important railway centres and places of tourist interest. The train comprised seven air conditioned coaches, a dining car, a medical officer's coach with dispensary, a luggage van and an observation car.

We left Delhi three quarters of an hour late owing to some of the delegates being delayed at their hotel. Consequently we lost our path and were held up by signal checks so that we did not reach Agra until rather late in the afternoon. We were able to see the Taj Mahal in daylight and have a quick look at the Fort. We then returned to our train till nightfall when we made our way back to the Taj to admire its ethereal beauty in the soft moonlight. Our train meanwhile had been standing at the main platform awaiting our pleasure, and it did not leave until we had finished our dinner and retired to our saloons at 11.0 p.m., having stood at the platform for 7 h.

We arrived at Varanasi at noon the following day and after lunch we toured the holy city of Banaras visiting Sarnath, the cradle of Buddhism, and drifted down the Ganges on ancient craft to view the burning ghats and temples alongside the river. We then drove through the grounds of the Hindu University, the largest in the East, with 10 000 resident students. We spent the night at Varanasi and after an early breakfast we ran on to Mughalsarai and inspected the marshalling yard. After lunch we left for Chittaranjan where we arrived early the next morning. We spent the day and following night at Chittaranjan, and on Monday morning we arrived at Howrah Station, Calcutta, in time for lunch at our hotels.

The whole tour was extremely well organised, and we were accompanied throughout by Mr. D. KUMAR and Mr. ANUP SINGH, of the Railway Board, and their charming wives. A train staff of 45 attended to our every want and the Medical Officer was most effective in curing the minor ailments suffered by some of the delegates. Apart from the late start from Delhi the programme ran to time and we received great hospitality wherever we went. I travelled on the footplate on several occasions and I make reference to my experiences later in this paper. I was impressed by the general air of efficiency and by the cleanliness of the stations through which

we passed. In some stations I noticed gangs cleaning the track, and at Varanasi I paid a surprise visit to the waiting and retiring rooms and found them in spotless condition.

Mughalsarai Marshalling Yard.

Reverting to the technical aspects of the tour the delegates spent a morning inspecting Mughalsarai Yard, the largest in India. It is at the focal point for the broad gauge railways of the Gangetic plain, where the Main and Grand Cord lines of the Eastern Railway from Calcutta join the Northern Railway lines to Allahabad and Lucknow.

The Up traffic from the East is mainly coal for distribution to districts on the Allahabad and Lucknow lines. Down traffic is largely made up of rakes of empties returning to the coal fields and exports for the port of Calcutta. Originally designed for a capacity of only 1 400 wagons per day each way, the yard is now handling nearly double this traffic with hardly any additional facilities. The efficient operation of the Up yard is the key to the work. It comprises 14 reception, 35 sorting and 12 departure lines. Trains of 70 loaded wagons are handled over the 9 ft. hump and despatched to the sorting sidings through points mechanically operated from a 40-lever frame, the lever man receiving advice by code from the controller alongside the hump. The present average through-put is 2 500 wagons per day, but as many as 3 200 wagons have been handled in 24 h. On the Down side conditions are easier and an average of only 1 400 of the 2 500 wagons need be put through the sorting sidings each day.

A major modernisation scheme is now in progress and the Up yard is being remodelled with a new hump and electro-pneumatic retarders. The eventual average daily capacity will be 4 000 wagons each way. The Down yard, however, is not being altered to any appreciable extent because most of the anticipated increase in traffic will be from coal and thus most of the Down trains will be empties which can go direct to the collieries. Fly-overs are being built at each end of the yard to increase the overall through-put of trains, and the whole area extending for over 4 miles between the Outer Home signals will be equipped with colour light signals. The delegates watched a train being put over the Up hump, and the chief point of interest was the speed with which so many wagons were handled in a simple mechanically worked yard.

Chittaranjan Locomotive Works.

The highlight of the tour was the visit to the Chittaranjan Locomotive Works on Sunday, 13th December. After an early breakfast a fleet of cars took the delegates to the administrative offices where we met the General Manager and the chief officers, and M. DE VOS placed a wreath at the foot of the bust of Deshanandhu Chittaranjan Das, an Indian patriot, after whom the works have been named.

The construction of this modern factory and its ancilliary township began in March 1948, and in less than two years production started. Output was

naturally slow at first, but it has risen steadily from 7 locomotives in the year 1950-51 to 165 in the year 1958-59, and it is anticipated that during the year ending March 1960, 175 locomotives will have been built. Production has been concentrated primarily on the standard W. G. class broad gauge heavy goods engine with 2-8-2 wheel arrangement. This powerful engine has a nominal tractive effort of 39 000 lbs at 85 % of the designed boiler pressure of 210 lbs per sq. in. Its total weight with 18 tons of coal and 5 000 gallons of water in the 8-wheeled tender is 177 tons. A few W.T. 2-8-4 tank engines are also under construction and orders have been received for the manufacture of 36 W.P. Pacific type passenger engines and a number of spare boilers.

The delegates were escorted through the workshops by officers who described the leading features. There were few men at work because Sunday is still observed as a day of rest. We were, however, very much impressed by the excellent lay-out, the modern machine tools and other equipment and the high inspection standards which are maintained, and not least by the enthusiasm and esprit de corps of the many officers with whom we came in contact. I was particularly interested in the welding of a locomotive steel bar frame and of a steel boiler which were in progress. Having seen the welders at work we visited the X-ray room where modern equipment is used to test the welds. The photographs demonstrated the remarkably fine results which are now being achieved. We were told that special attention is paid to the training of these welders who undergo a two year course before they are allowed to handle this high class work, and thereafter they receive refresher courses and tests every six months.

We watched a W.G. locomotive being « wheeled » and then drove to the Technical School where 120 apprentices and 20 embryo supervisors are trained. The apprentices' course lasts for four years and the supervisors' for five, half of which is spent in the workshops. The apprentices live in hostels and work in their well equipped shops.

The name Chittaranjan stands for much more than a railway workshop. It includes the modern well planned township of more than 5 000 quarters housing a population of 40 000 with all the necessary amenities for a comfortable civic life. The town has been laid out in separate colonies of self contained units, each with shopping centre, maternity clinic, schools, playground, dispensary, park, social amenity centre, and recreation institute. These amenities are comparable with the best European standards and each quarter is provided with electricity, filtered water supply and water borne sanitation. In addition, there are central institutes and a fine club, a well equipped hospital with 70 beds and an excellent sports ground. The township has cost almost as much to construct as the workshops, namely £5 millions against £6 millions for the latter.

The outstanding objective of the whole organisation is to obtain self-sufficiency in the supply of locomotives, and there is no doubt that the work

turned out in the shops bears comparison with the best in the world. The scope of production is being further expanded in order to increase self-sufficiency — this was a watchword which I heard wherever I went in India. Work on a steel foundry with an initial capacity of 7 000 tons per year is expected to commence shortly and a galvanising plant is to be set up for galvanising the steel masts needed for the new railway electrification projects, thus conserving foreign exchange. Although up to now work has been concentrated on the construction of steam locomotives, the manufacture of electric locomotives will shortly be undertaken. An order has been placed for ten 3 000 V D.C. locomotives and negotiations are under way for obtaining technical collaboration in the manufacture of 42 high voltage A.C. locomotives. The town is also to be extended and plans are in hand to build another 1 000 quarters.

Having seen the workshops and township and watched a local football match, the delegates motored to the Maithon Dam as the sun was setting in a pink haze behind it. This dam is one of a group which is being built to curb the monsoon activities of the turbulent Damodar River and its tributaries, and at the same time supply water for irrigation and hydro-electric power for industry. The Damodar River Corporation has been formed to execute and control this major project which has been likened to the Tennessee Valley Authority in the United States. The delegates visited not only the dam, but also the underground power house carved out of the solid black trap rock where three 12 000 K.W. turbines are installed. This station supplies energy to the grid at peak periods only in the dry weather, but it runs at full capacity during the monsoon. The works already completed have gone a long way to control this difficult river, but the 1958 floods were so severe that they were not fully controlled and did much damage.

Railway electrification in Bihar and West Bengal.

Reverting to our visit to Calcutta, I spent the afternoon of Monday, 14th December, on a tour of Garden Reach and other parts of the Calcutta Docks. In the evening the delegates attended a very pleasant party given by the General Managers of the Eastern and South Eastern Railways. On its conclusion some of the delegates motored to Howrah Station and boarded the special train for a visit to Dangoaposi on the southern fringe of Bihar to witness a trial run of the first high voltage A.C. locomotive in India.

In order to cope with the heavy increase in traffic resulting from the construction of new steel works and the development of industry in Bihar and West Bengal, the Railway Board decided to electrify some of its main trunk routes and heavily worked branch lines in that area. The 25 kV A.C. single phase 50 cycle system as developed by the S.N.C.F. was considered the best and the electrification of over 800 miles has been planned for completion during the Second Five-Year Plan. This is a departure from the original electrification policy, for the first phase of the Calcutta Electrification Project was the

installation of the 3 000 V D.C. system which is now in operation on 67 route miles from Howrah to Burdwan on the Eastern Railway main line and on the 22 miles branch from Sheoraphuli to Tarakeswar. The clearances provided on this system are, however, sufficient to allow for conversion to 25 kV A.C. in due course, and on the Bandel-Burdwan section the insulators carrying the overhead equipment are in fact designed for use with the high voltage system.

In view of the magnitude of the new electrification project an independent organisation under a General Manager and directly responsible to the Railway Board was set up to take charge of this work. Having selected the comparatively novel A.C. system the Railway Board considered it desirable to get help from an outside organisation with sound experience of this method of electric traction. Accordingly the S.N.C.F. were asked to co-operate, and they have been taken on as Technical Associates to give the Indian Railwaymen the technical « know-how » and to supervise the initial installations. A number of French engineers and other staff are at present seconded to the Indian Railways while some of the Indian railway officers and staff are in France studying the French system.

Our objective was the Raj-Kharsawan to Dangoaposi branch, some 46 miles in length, which carries the iron ore from the Gua and Banspani minor branch lines to the steel works at Tatanagar, 156 miles from Calcutta on the South Eastern Railway main line to Nagpur. The branch line has recently been doubled and is now in the process of being electrified. The only section ready for testing was the Up line from Kendposi to Dangoaposi, a distance of 12 miles. On arrival at Kendposi, we inspected the temporary sub-station equipment which had been obtained on hire from the S.N.C.F. Mr. P. N. MURTI, the Engineer-in-Chief of the Railway Elecfication project, closed a switch which energised the overhead equipment. We then went on to Dangoaposi where we admired the new 2 800 HP Bo-Bo type electric locomotive which was standing on the Up line looking very spick and span and garlanded with flowers. After the locomotive had been duly blessed and a coconut broken over the coupler, Mr. MURTI and the French delegates mounted the cab and drove off. It was indeed an historic occasion. I was very glad to be present.

The new locomotive weighs 75 tons with an 18 1/2 tons axle load and it produces a tractive effort of 32 480 lbs. It is designed to handle passenger trains of 680 tons at 70 m.p.h. on the level and at 45 m.p.h. up a 1 in 100 gradient. It can haul a freight train of 3 600 tons on the level at 40 m.p.h., or one of 2 300 tons at 30 m.p.h. up a 1 in 200 gradient. It has been built by a consortium of European firms, including French, Belgian, Swiss and German. Altogether 100 locomotives have been ordered from the consortium and orders for a further ten have been given to Japan. As mentioned earlier, negotiations are in hand for building other A.C. locomotives at Chittaranjan.

The branch line falls almost continuously from Dangoaposi, 1 531 ft. above sea level, to the main line and

consequently mineral trains of 3 400 tons can be handled down it; return traffic is empties. The iron ore is carried in large side-discharge hopper bogie wagons of 60 tons capacity and 30 tons tare weight giving axle loads of 22 1/2 tons. At the present time one passenger and 12 freight trains run daily in each direction, but this traffic is expected to be doubled when the steel works are developed to full capacity. Two 1 800 HP Diesel locomotives haul the freight trains at present, but they will be replaced by single electric locomotives as soon as work on the line is completed.

We had a pleasant run back to Calcutta where we arrived just in time to attend an excellent cultural show presented by the children of the Eastern Railway's Calcutta staff. We saw ten traditional Indian dances beautifully performed, and the exquisite costumes and graceful dancing were much appreciated. The following day, Wednesday 16th December, saw the break up of the I.R.C.A. party. Some returned to Europe, one or two flew to Madras to see the electrification works and then visit the Integral Coach Factory at Perambur, but the majority flew direct to Bombay so as to have time to visit the Ellora and Ajanta caves before inspecting the railway electrification works in that area.

I preferred to travel to Bombay by train in order to see the work on the railway, and I left that evening on the Bombay Mail. Prior to this I spent the afternoon with Mr. S. K. GOPINATH, the Chief Electrical Engineer, Eastern Railway, inspecting the Howrah car shed and examining some of the new 3 000 V D.C. electric stock. The shed was already well filled with the multiple unit stock and I had a quick look at the units supplied by the three manufacturers, British, Swiss and Japanese, but to the same general design and specification. Each three-coach set comprises a motor coach in the centre with a driving trailer at each end. It provides accommodation for 290 seated and 290 standing passengers, but on exceptional occasions it can carry an additional load of 290 standing passengers, giving a « dense crush » load of 870 passengers.

I also saw one of the Co-Co type locomotives of 3 120 HP. It is capable of hauling a 630 tons passenger train on the level at 70 m.p.h. and a 2 600 tons goods train at 40 m.p.h. I had previously ridden on one of these engines between Burdwan and Bandel when the special train was on its way to Calcutta. The locomotive had no difficulty in handling the 11-coach train, but as speeds were low it did not have a chance to show its paces.

The South Eastern Railway.

I left Howrah Station at 7.10 p.m. in a large and luxurious saloon attached to No. 2 Up, the Calcutta-Bombay Mail. Mr. A. K. MITRA, the P.R.O. of the South Eastern Railway, accompanied me and did much to make my journey comfortable and interesting. As already mentioned, my object was to see something of the extensive work in progress on this railway. This line is popularly known as India's Steel Plant Railway because it serves four of the five major steelworks in the country, namely the old established plants at Jamshedpur, near Tatanagar, and Burnpur, and the

new state-owned works at Rourkela and Bhilai, both on the Nagpur main line. The other state-owned plant is at Durghapur on the Eastern Railway, but most of its raw materials will be moved by the S.E. Railway. It is interesting to record that the three state-owned plants are being built with European assistance : Rourkela, German : Bhilai, Russian : and Durghapur, British. Each plant will have an annual capacity of 1 000 000 tons.

In addition to the steelworks other industries are being developed rapidly and by the end of the Second Five-Year Plan (March 1961) the S.E. Railway will be called upon to move nearly 7 000 loaded wagons daily — an increase of about 100 % in five years. To cope with this vast increase in traffic, railway facilities are being expanded in every direction; stations and marshalling yards are being enlarged and remodelled, and new yards are being built. Virtually the whole line from Rourkela to Nagpur is being doubled except for some major bridges and one or two short sections, thus practically completing the doubling from Calcutta. New branches are being built and 400 miles of the densely worked lines in Bihar and West Bengal are being electrified as part of the major electrification project already mentioned.

After a somewhat disturbed night caused by unruly passengers hammering on the shuttered windows of my coach at two stations en route, I awoke at Jharsugada, 320 miles from Calcutta, and from here to Nagpur, 480 miles further on, I saw work in progress at many places including the doubling in all its stages; formation work, track laying, bridges under construction, and completed sections carrying slow goods traffic. Single line working is being retained across the large rivers where the cost of doubling the bridges cannot be justified at present. These short lengths may be fully track circuited and controlled by direction levers so as to save drivers from picking up single line tokens at speed. This will be an improvement on the present arrangement whereby the engineman picks up on his bare arm a token on a bamboo ring at speeds of 50-60 m.p.h., though neither of the men seemed to mind this practice when I was riding in the cab of a W.P. engine between Bilaspur and Raipur.

Shortly after leaving Raipur we passed Bhilai where the Russians are supervising the construction of the large steelworks. In accordance with modern Indian practice, a complete new township is growing up with staff quarters, shopping centres, institutes, hospitals, etc. There was great activity on the railway, a new mechanised marshalling yard was being built and colour light signalling was being installed on a section of the main line. I noticed here and at other places on the railway that kilometre posts had been erected in addition to mile posts, and that wagon capacities and tare weights were being shown in tonnes and kilogrammes as well as in tons and cwts. This is in readiness for the next stage in the conversion of the country to the metric system. The coinage has already been changed to the decimal system and nayepisa at the rate of 100 to the Rupee have taken the place of the annas and pice.

On reaching Nagpur I left behind me the S.E. Railway after a most interesting day. I had been much impressed by the great amount of work in progress and the remarkable results already achieved.

The Central Railway.

For the remainder of my journey I travelled on the Central Railway (the old G.I.P. Railway), and I had another run on the footplate of a W.P. engine from Nagpur to Wardha before returning to my saloon for a bath and dinner. After another night in the train we reached Igatpuri, at the head of the Thul Ghat where I boarded one of the new mixed traffic 1 500 V D.C. electric locomotives. It is a Co-Co type developing 3 600 HP and capable of hauling passenger trains of 560 tons at 65 m.p.h., or freight trains of 2 000 tons at 45 m.p.h. It is equipped with regenerative braking and so did not require the assistance of a freight engine when handling our express train on the ten mile descent to Kasara on a ruling gradient of 1 in 37.

Extensive diversions have been made on the Ghat section so as to enable the structure gauge to be increased to take 12 ft. wide multiple unit stock in place of the old 10 ft. 8 ins. wide stock. The work was completed in 1949 but so far the multiple unit service terminates at Kalyan. Later in the day I saw even more extensive diversions on the Bhore Ghat on the Poona line.

Speed from Kasara to Kalyan was not high on account of the almost continuous curvature but the run was smooth and the track appeared to be in first class condition. On the outskirts of Kalyan there has been a great deal of industrial development and I saw several new rayon and chemical factories close to the line. At one place the fumes from a factory were causing corrosion of the rails and the overhead equipment was covered with a green sulphurous deposit.

Central Railway electrification.

On arrival at Kalyan I rejoined the I.R.C.A. party who had spent the previous day on a long and tiring outing to see the Ellora and Ajanta Caves and were now travelling by special train to Lonavla to see something of the Central Railway's electrified system. The train ran fast to Karjat at the foot of the Bhore Ghat. It was hauled by another of the new English Electric locomotives which had no difficulty in maintaining over long stretches the maximum permissible speed of 65 m.p.h.

At Karjat I boarded the engine for the run up the Ghats to Lonavla. For most of the 17 miles ascent we were on the new alignment which was brought into use after the War to improve clearances. The train was banked at the rear by one of the original freight locomotives supplied by Metropolitan Vickers Ltd. in 1929. These old veterans are still performing sterling service though it is becoming increasingly difficult to maintain them in first class condition.

After a tour around Lonavla by bus including a visit to the old reversing station to admire the extensive views of the Western Ghats the delegates returned to the special train for lunch which was served on the run back to Bombay. This was uneventful except for a check whilst

running through Parsik tunnel between Kalyan and Thana where large gangs were at work on track maintenance. I was much intrigued to see a large mirror at the mouth of the tunnel and I was told that it was used to reflect the sun's rays into the tunnel and that the light so produced was much better than a host of Tilley lamps.

On reaching the Bombay Suburban area I was reminded that the crows were not respecters of railway property and they caused interference by making their nests, largely of strands of wire, on the top of the overhead structures. Railwaymen have to be employed during the nesting season to restrain this activity and the insulators on the tops of the structures are now enclosed in boxes to prevent bird droppings from causing short circuits. This trouble has been experienced ever since the lines were electrified, and it is surprising that the crows have not yet learned to leave them alone ! Monkeys, on the other hand, learned their lesson years ago and nowadays they keep well away from the overhead wires.

On arrival at Bombay the I.R.C.A. visit to India ended with a press conference at which M. DE VOS and other delegates gave their impressions of the tour and expressed their great appreciation of the excellent arrangements and their admiration of the fine technical achievements of the Indian Railways.

That evening the General Managers of the Central and Western Railways gave a very pleasant dinner party and cultural show on the roof of the 7-storey office block recently built over Churchgate Station.

Locomotive running.

As I have already mentioned, I rode on the footplates of several engines during my travels. Altogether I had five runs on W.P. express passenger steam locomotives — three by day and two by night — and I rode in the cabs of electric locomotives on the 3 000 and 1 500 V D.C. systems on three occasions. The W.P. engine is now the standard for express trains throughout the broad gauge system. It is a powerful Pacific type weighing about 173 tons in working order and capable of hauling 16 coach trains at the maximum permissible speed of 60 m.p.h.

I was greatly impressed by the spotless condition of most of the steam engines on which I travelled. Their shining paint, polished brass and burnished steel were joys to behold. I discovered that they were allocated either to one driver or to a group of three drivers according to the shed practice and traffic requirements. These men took an intense pride in their engines which carried their nameplates; they not only kept them clean but pressed the maintenance staff to carry out promptly all necessary running repairs. By contrast, the South Eastern Railway engines are pooled and the cleanliness of the W.P. engine on which I rode was not up to the high standard of the allocated engines. On the other hand engine user was good. For example, mail train engines based on Chakradharpur run from there to Nagpur thence to Calcutta and back to shed — a round trip of over 1 400 miles in about 60 to 70 h including short breaks at Nagpur and Calcutta for examination and oiling. I

was told that at Bhusaval on the Central Railway where three drivers are allocated to an engine somewhat comparable results are obtained with the added advantage of getting cleaner engines and better maintenance. This seems like getting the best of both systems.

Third Class passenger travel.

I was interested to see for myself the improvements made in third class passenger travel since before the war, and on a visit to Delhi Station I inspected some of the new third class carriages. I found the standards of amenity much higher, with electric fans, decent lavatories and more room and light available for passengers. Another good innovation is the reservation of coaches for long distance travellers on selected trains. Separate coaches are provided for passengers travelling 151-300 miles, 301-500 miles, and over 500 miles. Seats can be reserved and an attendant travels in each of the carriages carrying passengers for the two longest distances so as to ensure that the carriages are regularly cleaned and watered and that attention is paid to any electrical or other defect. Third class sleeper coaches are also attached to some long distance trains, and the specially fast trains which run between Delhi and the three major centres — Calcutta, Bombay and Madras — include third class air-conditioned as well as ordinary coaches.

Overcrowding still occurs and this is particularly severe in the suburban areas. The multiple-unit trains in Calcutta and Bombay are filled to over-flowing, and it is a common sight to see passengers hanging out of the doors and sitting on the steps.

The railways suffer greatly from ticketless travel which is estimated to amount to 4 % of all travel with a consequential loss of about £3 millions annual revenue. Special steps have been taken to eradicate this and flying squads and many travelling ticket collectors are employed on this task.

Conclusion.

My tour of India was a most heartening and enlightening experience. I saw at first hand some of the fine achievements of the Indian Railways during the last 12 years. Many major works have been planned and executed by Indian railwaymen with comparatively little outside assistance. The staff has been enlarged to meet this expansion, and replacements have been found for the British officers who have left the Service since Partition. This has led to the rapid promotion of junior officers and the recruitment of large numbers of new ones. Many of them work long hours to keep abreast with the unceasing demands placed upon them, but devotion to duty and enthusiasm carry them through. There is, I feel a crusading spirit abroad, and railway officers are inspired by the knowledge that the prosperity of their country depends largely on the rapid and efficient growth of their railways.

Self-sufficiency is the watchword everywhere, and on the railways, for example, it has been and increasingly will be achieved at the Chittaranjan Locomotive Works. In other branches

of industry the drive is as great, as exemplified by the new steelworks and allied undertakings in Bihar and West Bengal, the foundation of a heavy electrical industry in Bhopal, and the growth of factories around the large centres of population. Self-sufficiency is vital for a country which is endeavouring to raise the standards of living of a rapidly increasing population, and whose exports are limited. It must be recognised, therefore, that India's main need from other countries is investment, both financial and technical, to help her found new industries and to develop existing ones.

I was particularly impressed by the high standard of new work on the railways where supervision is strict, but maintenance is a major problem affecting track, signalling, locomotives and rolling stock.

Acknowledgments.

Finally, I wish to express my appreciation and gratitude to the Chairman, Members and Officers of the Railway Board, and to the General Managers and Officers of the railways over which I travelled, for much of the information on which this paper is based and for their unfailing kindness, help and hospitality.

[625 .27 (44)]

Purchasing of supplies, markets, and operational research

(Exemplified by the purchase of wagon floor boards),

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SPECIAL ASPECTS OF THE PURCHASING OF SUPPLIES.

In the course of the administrative reorganisation of the undertakings which has been actively pursued for some twenty years, the handling of supplies has been fairly drastically modified. It would seem, however, that the efforts of the organisers have been almost exclusively concentrated on the accountancy aspects of the problem. They thought that an improvement in the accountancy of the materials would, in one move, resolve the complexity of the supply position. Such perfections are obviously indispensable for the establishment of criteria on which decisions can be based, just as good book keeping is essential to the preparation of the budget and of the capital investment programme of the undertaking.

To identify the supply problems with a more or less advanced mechanisation of book keeping is, however, not enough. It is obviously tempting to ascertain, in a more or less automatic manner, the quantities to be ordered and to entrust the « Supplies Clerck » (1) with the acquisition, at the best possible conditions, of the items required, calculated by a machine and audited by the accountants.

This unfortunate clerck, the « buyer » of the undertaking, slave of the calculating machines and dependent on a fluctuating market which governs his actions, has only very limited means of defence at his disposal. He finds himself the only human element in this world of electronics and economics. He does not repudiate the responsibility which has fallen on him, but he would be happy if the perfections of the modern world were, to him, not simply reflected in greater difficulties in carrying out his work.

When the Americans proceeded to use, for the management of large undertakings, large electronic data processing machines such as the IBM 705 or UNIVAC, they had little difficulty in transposing into the language and brain of these machines such problems of an almost solely book keeping or statistical nature as the pay rolls, expenses, receipts, etc. In contrast, the handling of supplies has been found more difficult to deal with, especially if one wanted to make the most of the potentialities of these electronic brains.

In practice, irrespective of the formulas which may have been adopted to ensure the replenishing of supplies, i.e. to determine the quantities for which orders are to be placed, difficulties arise from two uncertain factors :

— the determination of future consumption, and

(1) Cf. DETŒUF : « Les propos de M. Barenton, confiseur » (« The observations of Mr. Barenton, confectioner »).

— the knowledge of the actual periods of delivery.

The first factor is linked with the activities of the undertaking itself. It depends, in particular, on the sales programme, on the intensity of traffic (as far as the railways are concerned) and, often, on the cash position.

The second factor is outside the realm of the undertaking : it is intimately connected with the condition of the market from which the supplies are obtained.

These factors are not wholly independent of each other, since favourable sales prospects, calling for ample and rapid replenishing of stocks, often coincide with a market where the purchase of raw materials is difficult, and where deliveries are slow.

The uncertainties of future consumption, the economically justifiable quantities to be purchased, the « value analysis » — these are household words in the technical literature which, during the past twenty years or so, has become familiar to those who are concerned with the supplies problem. This literature originated in the United States where the subject is taught at the leading Universities. Very naturally, operational research has taken an interest in the subject and new formulas, largely based on probability calculations, have appeared.

Even so, it remains largely true that the purpose of such formulas is, essentially, to determine the requirements on the strength of factors *domestic to the undertaking*.

The American buyer has his sources of supply, which are often the same as those of his French colleague. But he enjoys the advantage of being able to obtain his supplies from a very large market which is in a process of continuous expansion and where, by and large, the production capacity increases as rapidly as the demand. It would be an exaggeration to state that the American buyer does not take delays in delivery into account, but these delays merely occur during short periods when expansion reaches a peak. In contrast, the French buyer has been, since 1940, up against almost continuous difficulties in trying to make his suppliers adhere to their terms of delivery.

It is not our intention to cast aspersions on French industrialists. The French economy has its own merits, and a rapid process of expansion, following a long period of stagnation, is bound to be accompanied by a degree of unbalance in the means of production.

* * *

It is therefore relevant to ask if the supply formulas exclusively based on the internal conditions of the undertaking, and on the assumption that the supply conditions are inexhaustable and regular, can really be applied to the French markets.

It is this question to which we shall try to find an answer by studying the example of a specific supplies item for the S.N.C.F. This study, set out in detail below, can be summed up as follows :

for the maintenance of wagon floors (of covered wagons, flat wagons, vans, and high-sided open wagons), the S.N.C.F. are buying, on an annual average, more than 45 000 m^3 of oak timber, representing *an expenditure, at current prices, of about* 1 200 *million francs*.

Currently known as « floor boards », these boards have a uniform thickness of 45 mm, whilst their length may vary between 2.35 and 2.90 metres, and their width between 170 mm and 260 mm.

The market in floor boards is a limited market which, in normal times, more or less conforms to the requirements of the S.N.C.F. and of the wagon builders. Production is divided among a great number of saw-mills, and the prices are largely influenced by the economic fluctuations. This market has therefore not much « flexibility ».

Up to a few months ago, the S.N.C.F. used to apply an absolutely general supplies formula which, apart from fixing the coefficients, had no regard to the peculiarities of the market. This lack of adaptation, as far as the supplies formula is concerned, entailed, in spite of a certain degree of constancy in consumption, important fluctuations in the stock position which were hardly compatible with sound management.

As a result of studies pursued with the assistance of an operational research team, recently set up at the General Research Department of the S.N.C.F., it has been possible to derive a general law from the rate of delivery of previous orders. As it was possible to verify the validity of this law over a very wide field, it was used as a basis for predicting the deliveries of orders on the book.

The problem is thus reduced to one of determining the demands, with due regard to the probable deliveries as well as to possible variations in consumption. The volume of orders to be placed depends largely on the probable trend of deliveries of new orders. It is closely related to the situation of the timber market.

Since, moreover, the price increases with the volumes of orders placed, the buyer is confronted with a dual « price-volume » problem in placing his orders. But he is not bound by any of the imperatives mentioned at the outset. He must see to it that his clients who use the floor boards receive, in good time, sufficient supplies to have an adequate quantity of seasoned timber available. The uncertainty of the development of the market still remains, but he is enabled to take an influence on the trends.

As far as sales problems (i.e. » marketing », to use a topical term) are concerned, market research is an indispensable basis for all serious research. It is a matter for regret that this has not been so with purchasing problems. To ask a buyer to place an order for immediate delivery of an important quantity of strategic raw materials in a period of international tension is just as unreasonable as asking the head of a sales department for the immediate disposal of 200 000 domestic appliances in a period of recession.

The head of the sales department would be immediately able to produce graphs and statistics to prove the futility of such an effort. The buyer, on the other hand, can often only oppose this request by his experience — and by lack of success.

Up to now, operational research has been almost exclusively concerned with problems of sales as a function of the market. As far as purchases are concerned, these problems did not seem worthy of the attention of the research workers, unless the problem appeared to be too difficult to them.

It must not be forgotten that the acquisition of materials often represents more than half, and even more, of the expenses of an undertaking concerned with the manufacture of new products. The part played by materials in the maintenance expenditure of large public utility undertakings also remains an important factor.

There can be no doubt that the money spent on operational research on purchasing is a worthwhile investment. The following pages constitute a modest contribution to the exploration of this new sphere.

* * *

Example of the purchasing of supplies as a function of the market.

The production of floor boards is only one of the minor activities of the timber industry. There exists, however, a market in floor boards, with all its specific features.

FLOOR BOARDS IN FRENCH FORESTRY.

As with all the articles purchased by the S.N.C.F., the quality of floor boards is laid down in a technical specification, which need not be quoted here. But is it relevant to point out that most of the French oakwood saw mills are fully familiar with the « floor board » quality, just as they are familiar with other qualities such as « cabinet-making », « fine-joinery », and « sleepers ».

If France is the country of oak forests,

it is still extremely arbitrary to try and define a « standard tree », because of the diversity of soils, of climates, and of forests. It is however possible to distinguish between three more or less important parts, according to trees and region. The « log » extends from the foot of the tree to the first major knot; the « first upper log » from the first major knot to the crown of thick branches; and the « second upper log » from there upwards, constituting the highest part of the trunk.

boards, al other things being normal, can be estimated at 60 000 to 70 000 m3.

For the transport of goods, the S.N.C.F. do not require floor boards of a quality superior to that laid down in the technical specifications.

On the other hand, they consistently refuse to use timber of inferior quality which might cause accidents, or damage to the loading. *The resources of the market on which they are able to buy under economic conditions are therefore limited* (1).

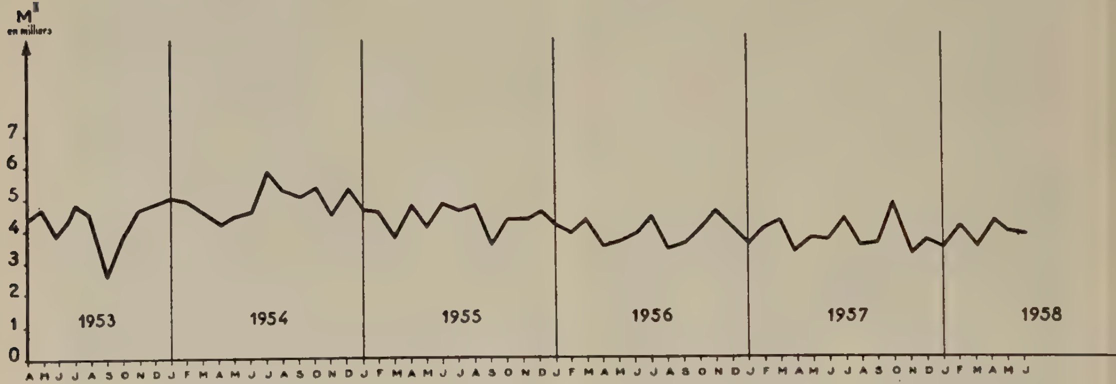

Fig. 1. — Monthly consumption of floor boards (in thousands of cubic metres).

The « log » is the high-quality timber used for veneering, cabinet-making, and joinery. The « second upper log » consists of knotty wood of comparatively little value which is, however, well suited for railway sleepers. It is from the intermediate part, i.e. the « first upper log », that the floor boards are obtained.

In view of the fact that the length and diameter of the first upper log may vary considerably, the cubature of wood which can be used for floor boards without unduly onerous sawing operations is, on the whole, rather limited. The French output amounts to about 1 million m3 of oak timber per annum. Since framework timber, parquet framing strips and even coffin boards are also obtained from the first upper log, the maximum quantity available for floor

But the production is greatly divided since there are many (in fact, according to the experts, too many) sawmills in France, and their individual output, in oak timber alone, varies every year from a few hundred to several thousand cubic metres. The corresponding cubature of floor boards may therefore vary from a few cubic metres to several hundred cubic metres.

As the minimum quantity which the S.N.C.F. will purchase is 12 m3, correspond-

(1) We shall, later on, revert to the price questions. The greater the cubature purchased, the higher become the prices. It may be assumed that the last cubic metres purchased are of a quality higher than that of the first. The sawmills are tempted to reserve, for the floor boards, the part of the log adjacent to the upper log, if they regard the prices as satisfactory.

ing to a wagon load, they must consult more than 800 suppliers in order to ensure that their requirements are met. It is, incidentally, rather symptomatic to find that the average order placed every year with the individual sawmill hardly exceeds 100 m³ and that, with rare exceptions, no single order exceeds 1 000 m³.

In practice, the floor boards are not obtained in a continuous operation. The first concern of the sawmills is to make the most of the rough timber which they buy at relatively high prices, and floor boards are only obtained from wood of the corresponding quality. In view of the economic conditions of the market, the floor boards appear to be a kind of « by-product » of French forestry. On the assumption that a supplier reserves his whole production for the S.N.C.F., the rate of production will primarily depend on the quality of the timber handled.

Finally, timber is a material subject to speculative trading, and its price may fluctuate within fairly wide limits. Suffice to point out that the prices in force at the end of 1957 nearly reached those of 1952, having undergone, in 1953, a slump of more than 30 %. Timber, like most raw materials, is greatly influenced by fluctuations in the general economic position.

CONDITIONS FOR THE PURCHASE OF FLOOR BOARDS.

The formula normally used by S.N.C.F. for the replenishment of stocks is :

$$Q = K\ (P + L + S) - (R_1 + R_2 - D) \quad (F)$$

where :

- Q = the quantity to be ordered;
- K = the estimated *future* monthly consumption of the article;
- P = the normal interval, in months, of successive purchases;
- L = the delivery period in months;
- S = the safety margin of stock in hand per month;
- R_1 = the quantity of material in stock;
- R_2 = the quantity on order but not yet delivered at the time to which Q applies.
- D = the quantity required by the users which could not be met from stocks (1);

In the case of floor boards, the formula used to be applied under the following conditions :

- P = 6 months : re-plenishing of stocks takes place twice a year after the large autumn and spring sales;
- L = 9 months : being the average period of delivery ascertained; in practice, the contracts provide for two different delivery periods, one from six to nine months, and one from nine to twelve months;
- S = 10 months : being the period storage which corresponds to the seasoning period of the timber; the latter is received as fresh timber from the suppliers but is not used before it is seasoned.

The formula quoted above is arithmetically perfect and takes into account all the factors which may have a bearing on the quantity to be ordered. Moreover, as will be seen from figure 1, the monthly consumption has been relatively constant since 1953. It might therefore be expected that the application of this general formula should have given satisfactory results. In practice, however, this is not so.

DRAWBACKS OF THE CONVENTIONAL FORMULA.

In spite of the staggering of supplies envisaged in the orders, deliveries are irregular. Instead of obtaining a balance between the quantities of timber coming in and timber used, which would have resulted in a constant quantity being kept in stock, there have been, as figure 2 shows, considerable fluctuations in the quantities in stock since 1952.

Any quantity in stock which differs

(1) Theoretically, with $R_1 > 0, \quad D = 0$;
with $R_1 = 0, \quad D \geqslant 0$.

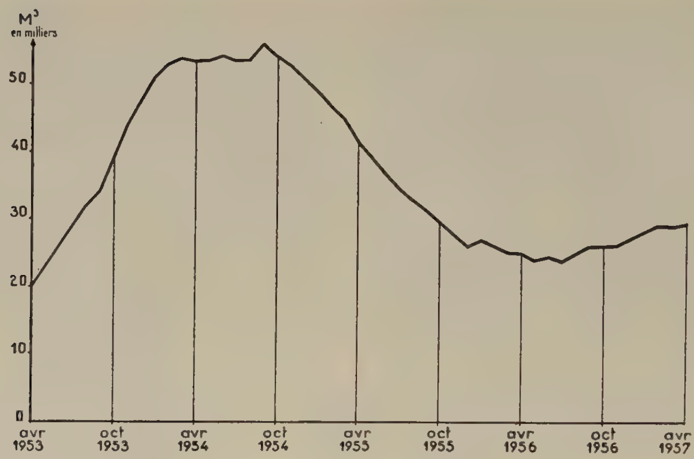

Fig. 2. — Variation in the level of stocks (in thousands of cubic metres).

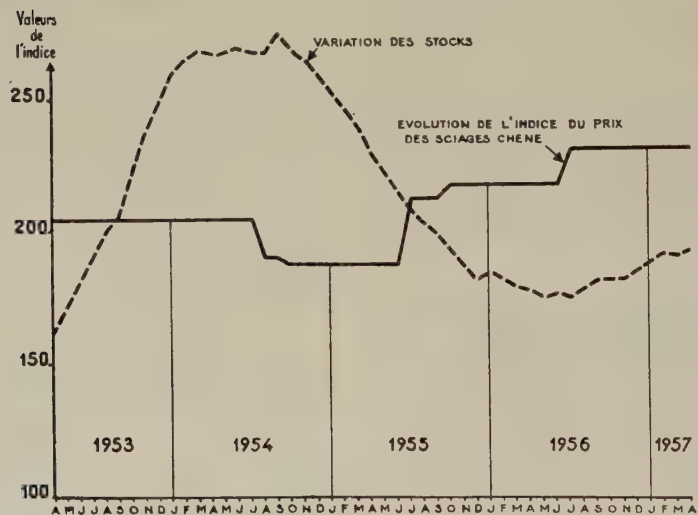

Fig. 3. — Comparison of the stock level fluctuations with the official price index for sawn oak timber.

from the theoretical quantity, either on the high side or on the low side, gives rise to disadvantages. Even without leading to actual shortage, an unduly low quantity in stock means inadequate seasoning of the timber so that the boards mounted on the wagons tend to shrink and the wagons become untight. An unduly large quantity in stock will increase the financial charges : one month of stock in hand means the immobilisation of 100 million francs.

Moreover, if the graph of figure 2 is

compared, in figure 3, with the fluctuations of the official index for oak timber, it will be found that, during the period of the slump when the index was at its lowest, the quantity of timber in stock was at its highest so that few purchases were made. During the period of rising prices, the situation was reversed, and purchases had to be made at high prices. This state of affairs it not conducive to an economic purchasing policy, and prevents the S.N.C.F. from playing a part in stabilizing the market. It is, in fact, during periods of recession that the railways should enable their suppliers of long standing to dispose of the products which they cannot sell for export or on the home market.

WHAT ARE THE REASONS FOR THE ANOMALIES.

Among the most frequent causes for the variation of quantities in stock are the fluctuations of the monthly consumption figures, K. In fact, in the formula quoted above, the multiplication factor of K is 25 and a variation of K, even a small one, entails an important modification of the quantity to be ordered.

If formula (F) was conducive to such fluctuations of the quantities in stock, this was also due to the fact that the suppliers did not adhere to the specified delivery periods, L.

Where deliveries take place too early, it is always possible, as is the normal practice with the S.N.C.F., to delay the payments so as to force the sawmills to adhere to the delivery periods laid down in the contract. But the interval between the purchase of cut timber and the delivery of the finished product is always considerable so that the timber merchants are forced into large-scale credit-taking. If payments are delayed by three or four months after the actual date of delivery, there is, during a period of slump, a risk of a great number of suppliers getting into a very difficult financial position. This measure can therefore only be resorted to with caution.

Moreover, the speed-up of deliveries was often called for in respect of old orders where the delivery periods laid down in the contract had expired.

During 1957, the Purchasing Department made an attempt to improve its methods and got in touch with the operational research team.

Close collaboration between the two departments gave rise to a thorough analysis which is outlined below.

REPLENISHING OF STOCKS AS A FUNCTION OF THE MARKET.

The problem consisted of two distinct parts :

— The market in floor boards, where the main features were known, seemed to respond to specific laws, as a function of a number of factors; it was necessary either to determine these factors, or to find a sufficiently representative general law where the market features were not of a purely random character.

— Replenishing of stocks was based on an elementary formula which was, however, not suitable to take the market fluctuations into account over a sufficiently long period of time. In other words, the attempt had been made arbitrarily to apply, to a complex phenomenon, a simple formula which was not capable of expressing the activity of the suppliers as a whole.

ANALYSIS OF DELIVERIES.

Previously, the delivery statistics only used to show the total cubature received each month, without being concerned with the date at which the corresponding orders had been placed.

It was therefore decided to review all the orders placed since January 1952, classifying them by the month in which they were placed, and to ascertain the rate at which the quantities ordered during a given month had been delivered.

In practice, the cubature delivered during the month $M + n$ is the sum of the cubatures delivered in respect of orders placed during the months M, $M + 1$..., $M + k$..., $M + n - 1$, on the assumption that all the timber

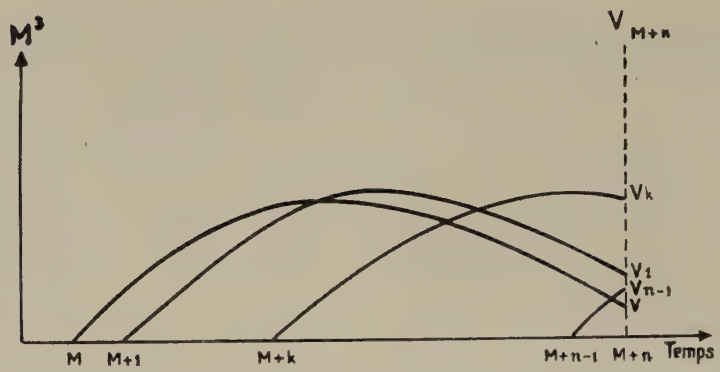

Fig. 4.
N. B. — Temps = time.

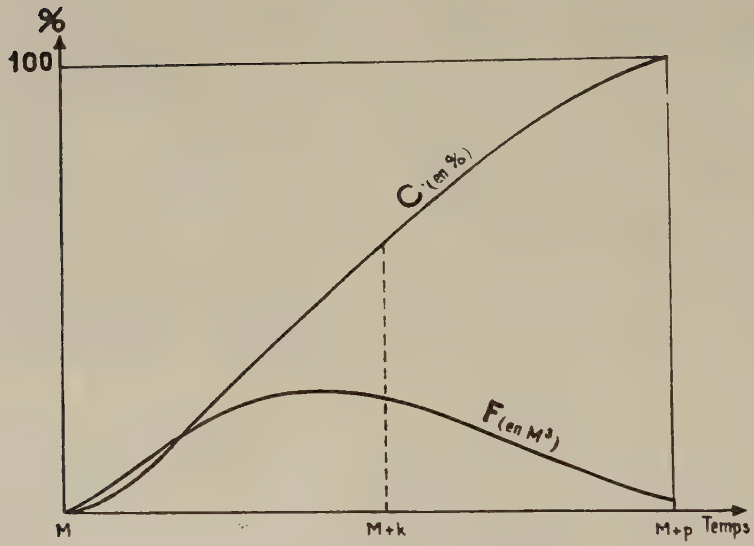

Fig. 5.
N. B. — Temps = time.

ordered during the month M — 1, has been delivered.

It will be seen from figure 4 that the total cubature V_{M+n} consists of :

$$V_{M+n} = V + V_1 + \dots + V_k \dots + V_{n-1}.$$

All the curves were plotted for the years since 1952, and translated into aggregate cubatures. In figure 5, the curve marked F, indicating the number of cubic metres delivered each month in respect of orders placed during the month M is matched by curve C indicating the aggregate percentage of deliveries.

If Q is the total cubature for which orders had been placed during the month M, and if q_1 ..., q_k ..., q_p are the part-cubatures delivered during the months M + 1 ...,

$M + k$ ..., $M + p$ (last deliveries), respectively, the ordinate of curve C corresponding to the abscissa $M + k$ amounts to :

$$\frac{q_1 + \ldots\ldots + q_k}{Q}.$$

In this way, one obtains a family of curves C, some of which are reproduced in figures 6 (monthly orders exceeding 10 000 m^3) and 7 (monthly orders for quantities between 6 000 and 10 000 m^3). An examination of these families of curves gives rise to the following observations :

1) In practice, deliveries begin to come in already during the first month after the order had been placed.

2) To all intents and purposes the deliveries cease (1) after a period of time ranging from 10 to 25 months.

3) Above a certain percentage, viz. around 85 or 90 %, the curves become irregular for reasons akin to those mentioned in footnote (1).

4) It is possible to distinguish between two characteristic families of curves : those representing rapid deliveries (February 1954, June 1953), and those representing slow deliveries (June 1955, February 1956).

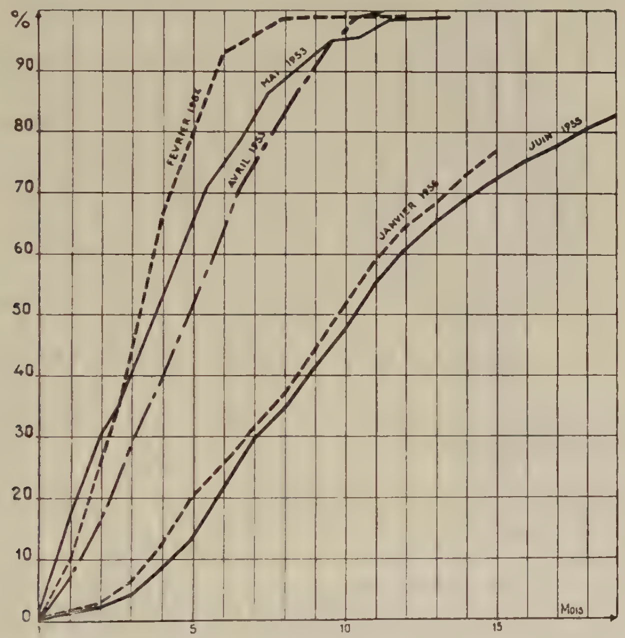

Fig. 6. — Cases of monthly orders exceeding 10 000 m^3.
N. B. — Mois = months.

These curves are of a complex nature. They reveal, however, certain similarities, and an attempt has been made, by graphical means, to represent them in a simpler form.

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(1) Delivery beyond 97 % can only be obtained by the threat of legal proceedings against defaulting suppliers and, in some cases, only by recourse to the courts.

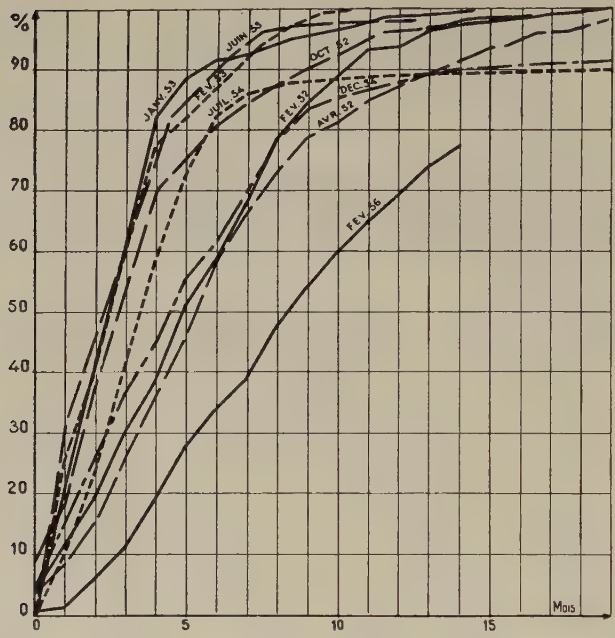


Fig. 7. — Cases of monthly orders ranging from 6 000 to 10 000 m³.

GRAPHIC TRANSFORMATION OF THE DELIVERY CURVES.

The operational research team tried out several methods of curve fitting; *the one which proved to be by far the best was the logarithmic-normal model.*

This is a classic law of probability where the logarithms of a set of variate values are distributed according to a normal (Gauss) distribution.

In other words, a variate x follows a logarithmic-normal law if the variable

$$u = \mathrm{L}\,(x - x_0)$$

itself follows a normal law (x_0 being a constant).

Let us briefly recall the nature of the transformation which permits the representation of a normal distribution by a straight line.

By way of example, the table hereafter shows the monthly deliveries in fulfilment of orders placed during February 1954 and January 1956, respectively.

Orders	February 1954	January 1956
Quantities ordered	13 245 m³	18 664 m³
SUCCESSIVE DELIVERIES	0 1347 2179 2431 2797 1810 1754 388 359 34 0 0 17	9 303 234 653 1150 1377 1008 1092 1042 1344 1374 1323 1069 760 832 718

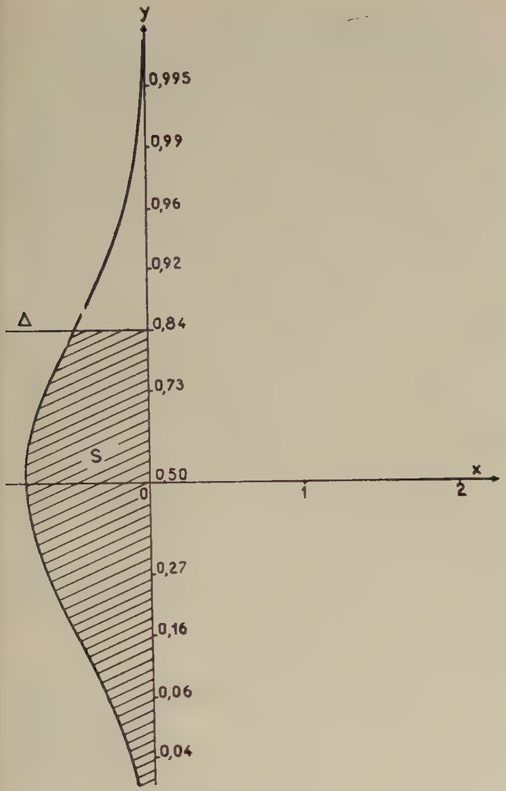


Fig. 8.

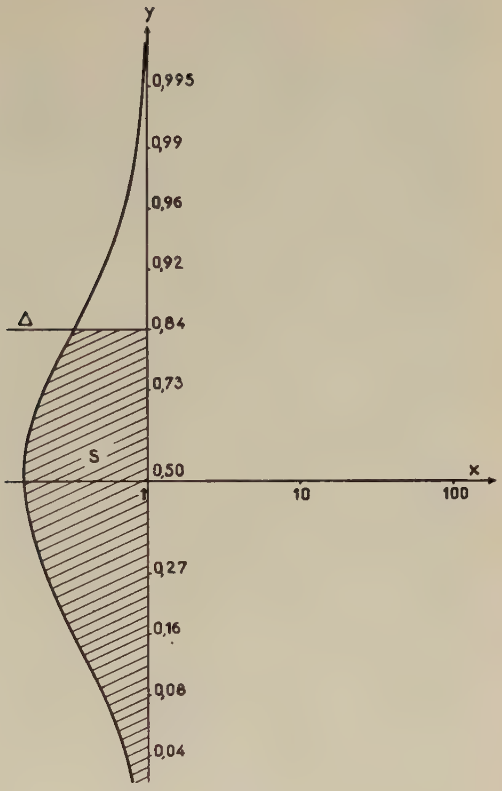


Fig. 9.

Figure 8 shows two axes of rectangular co-ordinates and a Gauss distribution curve of the equation

$$-x = \frac{1}{\sqrt{2\pi}} e^{-\frac{y^2}{2}}$$

(« cocked hat curve »), designed by taking the y-axis as a base.

Let us now consider a straight line Δ parallel to the x-axis, and the hatched area S below that straight line. At the point where Δ intersects Oy, we note the value of the area, and we repeat this procedure for a great number of different positions of Δ. We thus obtain a new system of coordinates where any cumulative normal distribution is represented by a straight line. In particular, the function

$$y = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{x} e^{-\frac{x^2}{2}} dx$$

is represented by the first bisectrix of the axes.

We now transform the graduation of the x axis by substituting, for the numbers 0, 1, 2......, x......, the numbers 10^0, 10^1, 10^2......, 10^x...... (fig. 9). We thus obtain a system of Gauss-logarithmic coordinates in which any logarithmic-normal distribution is represented by a straight line.

This is the law that has been found to apply to the cumulative deliveries of wagon floor boards, expressed as the percentage of the quantities ordered, and on the understanding that the value of x_0 is — 5, i.e. that the orders were placed during the month M — 5.

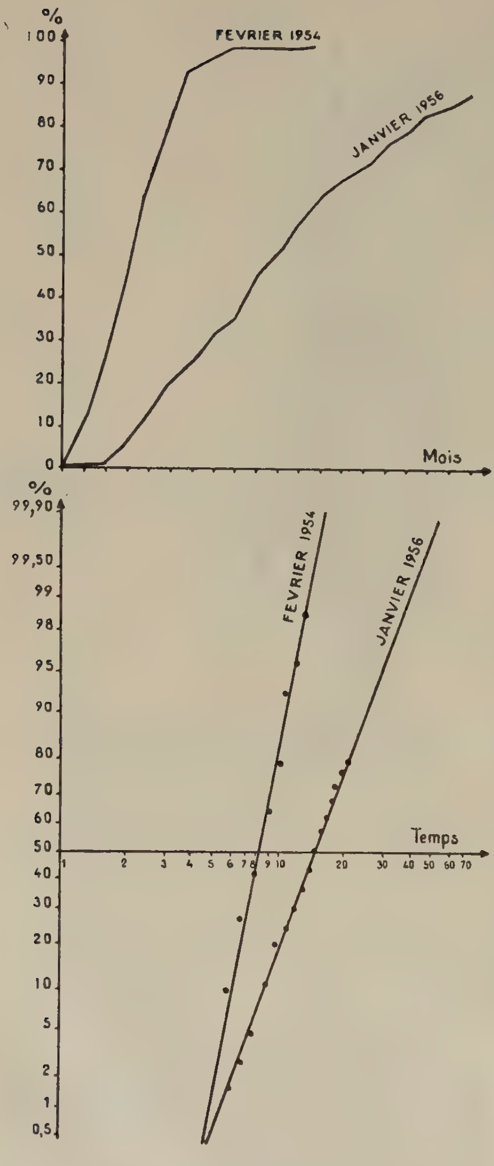


Fig. 10.

N. B. — Mois = months. — Temps = time. — Février = February. — Janvier = January.

Figure 10 shows the corresponding cumulative delivery curvers in Cartesian coordinates, and in Gauss-logarithmic coordinates.

For the months in which the volume of orders placed is small, i. e. below 400 m³, the alignment is only very approximate. This shows that the linear rate of deliveries is only realized with important quantities, which, incidentally, applies in the majority of cases. Figure 11 shows the example of September 1954 when the quantity ordered was 180 m³. It will be seen that the anomalies of the last deliveries are also apparent on the straight lines. Beyond 85 %, the points representing the deliveries are, as a rule, no longer in alignment.

A straight line is, after all, theoretically determined by two points. In the present case, it was found that, by and large, it is possible to plot the straight line of deliveries with good approximation as soon as three points or, better still, four points are known, corresponding to some 10 % to 15 % of the cumulative deliveries.

To sum up, it is possible to represent the fulfilment of the orders for floor boards in a graphically simple form.

It is not our intention to investigate, in this connection, the deeper reasons why these deliveries should follow a logarithmic-normal rate. The authors have advanced several working theories. The most probable one takes into account the lack of flexibility of the market and the great number of suppliers which is relatively constant over the years. As a rule, a supplier will only offer to the S.N.C.F. a cubature which is approximately proportionate to the prospective timber cuttings from which he had worked out the likely yield in floor boards. If the prices rise (in a period of boom), he will not be in a hurry to deliver timber at comparatively less remunerative prices. During the following campaign, the prices agreed by S.N.C.F. will be higher, but as his deliveries will be affected by the priority of the earliest orders, the fulfilment of the old orders must necessarily be speeded up if the supplier wants to have the benefit of better prices. During a period of recession, the supplier will hasten to clear his order book in order not to risk the cancellation of old orders based on the higher prices.

As far as the interval of five months bet-

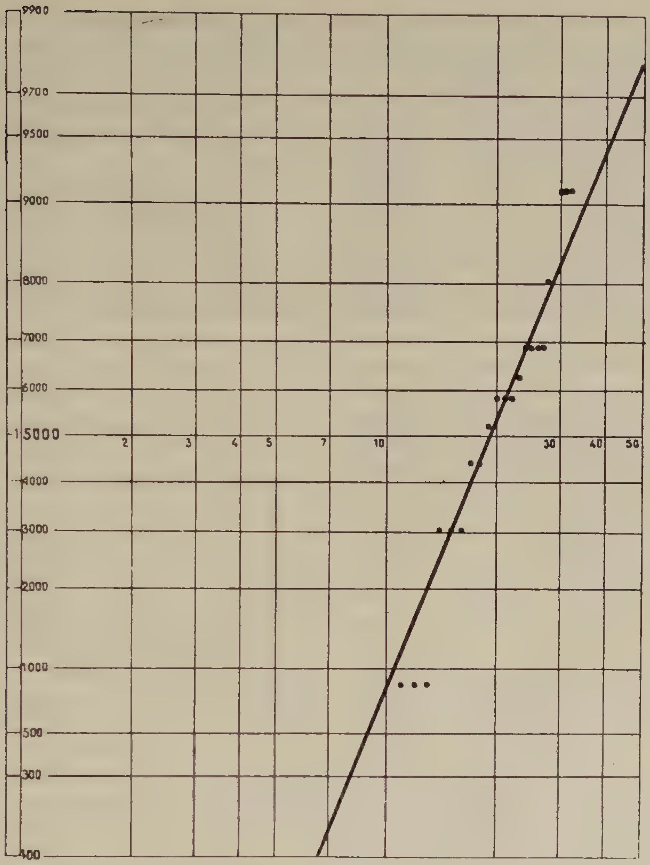


Fig. 11. — Deliveries on the strength of orders placed in september 1954.

ween the date of the order and the origin of the reference curve is concerned, this may well be attributed to the interval of six months which normally intervenes between successive calls for tenders put out by the S.N.C.F. Our suppliers know that they will be able to supply, as a result of the next call for tenders, those lengths of timber without other use which have accumulated with them since the last call for tenders.

NEW FORMULAS FOR THE REPLENISHMENT OF SUPPLIES.

We may now revert to figure 4 and assume that the month M + n corresponds to a normal period of order-placing (1). The problem confronting the buyer is that of determining the quantity to be ordered and the price to be fixed for the current campaign. As we shall see later, these two factors are not wholly independent of each other. However, the quantity to be ordered must be such as to keep, during the coming months, the level of timber in stock at its

(1) Generally, the attempt is made to place the 400 orders of a normal replenishing campaign within the shortest possible time. In practice, however, the orders are spread over two or three months owing to the slowness of correspondence on the part of some suppliers.

optimum. We may assume that the stock level during the month $M + n$ is normal, and that it is desired to keep it at that level during the following months. Moreover, the consumption schedules or the trends arising from the maintenance programmes are known. To simplify the notations, we shall use the term M_1 for the month $M + n$.

To the curves of figure 4 correspond a certain number of straight lines, representing the deliveries of the previous orders not yet fully cleared. In view of the periodicity of six months, which is closely related to the habits of the market, the last orders of the previous campaign would be three months old. These are, incidentally, generally concerned with minor quantities, as the great majority of the orders would have been placed four or five months ago.

The straight lines representing the deliveries are thus sufficiently determined, even for the last orders. To facilitate the conversion into cubic metres of the percentages indicated by the graph, it is possible to obtain, for each month of order-placing, the expected deliveries during the following months. By adding them up, one obtains the total quantities likely to be delivered. In the knowledge of a planned consumption, it is possible to work out the additional quantity which must be supplied in order to keep the stock level constant.

This calculation is made clearer by figure 12. The summation of the deliveries expected during the months $M_1 + 1$ ... $M_1 + r$ ... yields curve C. The expected monthly consumption figures may be those represented by the straight sections C′. The differences of the ordinates of C and C′, marked v_1, v_2..., v_k corresponding to the months $M_1 + 1$, $M_1 + 2$ ..., $M_1 + k$ ... (full lines on the graph) show to what extent the deliveries will exceed, or fall short of, the quantities required to keep the level of stocks constant. The volume of deliveries required to maintain the level of stocks until the month $M + n$ is therefore: $V = - v_1 - v_2 + v_3 + ... + v_k + ... + v_n$.

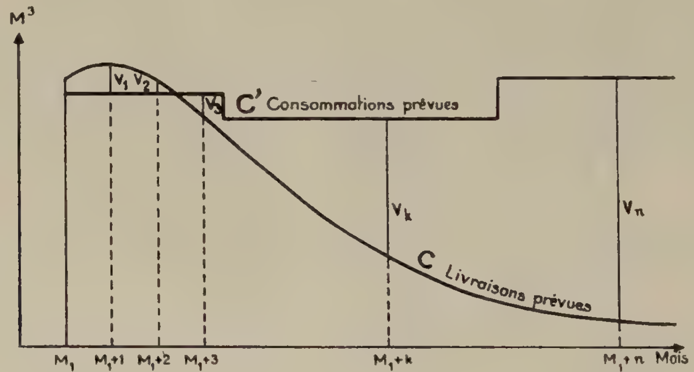


Fig. 12.

N. B. — Mois = months. — Livraisons prévues = expected deliveries. — Consommations prévues = expected consumption rates.

What is the approximation to V ? It is still too early for it to be known with precision. However, since the new method was evolved, forecasts have been made on a trial basis. Six months later, the maximum difference between the deliveries forecast and the total deliveries actually made during that period was found to be 10 %.

In order to make the explanation easier, we have assumed that the stocks were, during the month M_1, at their normal level.

If this is not the case, the volume V must be correspondingly increased or reduced.

Having thus set out the principles of the new method, we shall now examine the possibilities of its practical application.

PRACTICAL APPLICATION OF THE NEW FORMULAS.

We know the quantity of the *deliveries to be expected* during the months $M_1 + 1$, $M_1 + 2$ ... in respect of orders placed during the month M_1. From these data, it is necessary to deduce *the volume of orders* to be placed, and *the price* which should be offered.

a) **Determining the volume of orders to be placed.**

There can obviously be no question of obtaining each month a level of stocks exactly conforming to the theoretical level. The method indicates the general trends of deliveries. In the month M_1, a target is fixed for the month $M_1 + n$. After some studies, a figure of $n = 6$ was chosen. Thus, in June 1958, one has tried to determine the volume of deliveries that must be received until December 1958 in order to obtain, by 31st December 1958, a level of stocks more or less in keeping with the theoretical level.

The volume of the orders to be placed will thus solely depend on the rate of deliveries during the next six months. All the delivery curves for the time from January 1952 to June 1958 are available. Since January 1952, the timber market has, successively, gone through a period of intense activity coinciding with the Korea war, a fairly marked recession at the end of 1953 and early in 1954, and again an expansion up to the beginning of 1958. These six years thus represent a complete economic cycle, and the delivery curves follow the market fluctuations with a certain regularity :

— slow deliveries in a period of expansion;

— rapid deliveries in a period of recession.

Each curve thus corresponds to a well « defined » state of the market. The problem therefore consists in analysing the present conditions of this market and, in particular, in predicting the future conditions. The function of the buyer is thus not confined to the placing of the orders at the most favourable price; he must also study the economic background inasmuch as it has a bearing on his purchases.

For this purpose, he has a number of market data available : the trend of export demands (France exports every year important quantities of logs and sawn timber), the general response of the suppliers to the S.N.C.F. orders, etc. From a study of the general and technical press, from conversations with suppliers, from regular visits to the producer regions, and particularly from the market pointers supplied by the great forest sales in the autumn, he is able to form an opinion of the evolution of the market.

All these criteria must be reflected in the selection, at the time when orders are due to be placed, of an appropriate curve of probable deliveries, i.e. a straight line in the gauss-logarithmic system of coordinates. From this line, the buyer is able to deduce that by the end of the sixth month, n % of the quantities ordered now are likely to be delivered, and as he knows the quantity which he would like to have delivered by that time, he can work out the total quantity of floor boards, P, for which he must place orders :

$$P = V \cdot \frac{100}{n}.$$

b) **Fixing a campaign price.**

During each campaign, enquiries are sent out by the S.N.C.F. to those of their 800 suppliers whose deliveries have followed a regular rate. The suppliers are requested to state the cubature of floor boards which could be supplied within the normal delivery periods, and the price conditions.

The offers are classified by means of punch cards in increasing price order and,

taking into account the cubature offered, the S.N.C.F. draw up a cumulative curve such as that reproduced in figure 13, showing that, at a price below or equal to

$$P_0 + 3\,000$$

the cubature offered amounts to 7 500 m³. Experience shows that, if a price P_1 is fixed, it is possible to obtain, after negotiations, a volume in excess of V_1.

The determination of the price P_1 is thus a matter of the greatest importance as the price must be sufficiently attractive

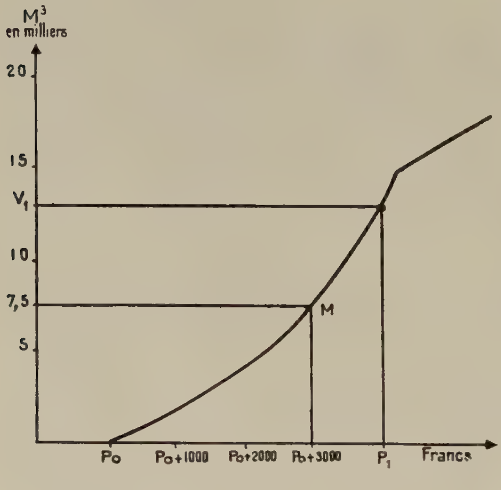


Fig. 13.

N. B. — M³ en milliers = in thousands of m³.

to secure the volume V. If the price P_1 is fixed too low, the negotiations with the suppliers who have quoted a higher price will not ensure the placing of orders for the desired volume V, and it would be out of the question to have recourse to a second price P_2, higher than P_1, during the same campaign, as the psychological effect on the suppliers would be disastrous.

Conversely, if P_1 is fixed too high, the S.N.C.F. will incur excessive expenditure in the purchase of floor boards. This error becomes immediately apparent if, after the orders for volume V have been placed, those suppliers who had quoted very high prices and with whom negotiations were not contemplated ask to come into line with the campaign price, in spite of the initial difference between that price and their offer.

Finally, a last question arises :

Should one, in all cases, purchase the volume of floor boards indicated by the new method ?

It has been assumed, so far, that the quantities in stock had reached their optimum level and that it was desired to maintain that level.

This rule might be challenged in certain cases, viz.

— if the prices are high, and are likely to be lower during the following campaigns;

— if the prices are low, and are likely to rise.

In the former case, it would seem to be in the best interest of the S.N.C.F., to go in for a temporary reduction of stocks and, in the latter case, for temporary over-stocking.

The new method is well suited for the solution of this problem, but other factors also have a bearing :

— what is the technical risk involved in using floor boards with excessive moisture content ?

— what is the cost of an additional immobilisation of capital for material in stock, including all the consequential costs (interest on capital, storage difficulties, increased fire risks, etc.)?

The answers to these question call for further investigations which we shall merely mention, as they constitute the natural corollary to the study of stock replenishing methods on a market with large price fluctuations.

* * *

CONCLUSION.

VALUE OF THE NEW FORMULAS.

If operational research leads to purely mathematical methods, it is easy to verify

these methods by applying them retrospectively to earlier situations. Such a verification is less easy in the case of the floor board market. It was easy to establish that the increase or shortage of stocks during the last few years could have been foreseen with an anticipation of between six and twelve months. Before the level of stocks has reached a maximum or minimum, the requirements expressed by the conventional formula should have been decreased or increased. The study of the known delivery curves would have revealed these tendencies.

For a complete verification of the method, it would have been necessary also to determine the curves of future deliveries, i.e. to review, on the strength of the position encountered in 1952 or 1955, the principal economic data and to make forecasts for the next six months, or longer. It seemed to us, after some earnest attempts, very difficult to make predictions for a future which was, in reality, already in the past. Whatever analysis of the future trend could have been made, the determination of a straight line representing the deliveries which were, incidentally, well known, might be deemed arbitrary and would automatically deprive the verification of any value.

PARTIAL REHABILITATION OF THE CONVENTIONAL FORMULA.

As has already been stated at the outset, an arithmetically perfect formula is already in existence which has, among its main advantages, the one of being simple. It is always psychologically difficult to cast aside a useful tool and to replace it by a complicated machine of not readily obvious usefulness.

Why should it be necessary to abandon the conventional formula :

$$Q = K\ (P + S + L) - (R_1 + R_2 - D)\ ?$$

The various operations which we have discussed are more or less identical with those expressed in the formula. They take, in fact, into account the future monthly consumption figures and their variations; the delivery periods enter into the calculation of requirements, and the subtractive term

$$R_1 + R_2 - D$$

is also taken into account in the new formula.

However, L and R_2 are no longer simple terms. What value should one attach to L, knowing that the actual delivery periods may vary from one to 18 or even 24 months and that, in most cases, the compliance with the orders does not reach 100 % or is at least, infinitely slow in the vicinity of that percentage ?

The deliveries recorded around a date t will follow a complex law in which the general market trend :

$$dQ = f(t)\ dt$$

plays a part, and the quantity Q will be delivered by the end of a period of time T so that :

$$Q = \int_0^T f(t)\ dt.$$

One might take, for L, a mean date so that, e.g.

$$\int_0^L \cdot (t)\ dt = \frac{Q}{2}$$

and, having adopted this definition, try to express it as a function of the gradient of the straight line representing the deliveries in a Gauss-logarithmic system of coordinates :

$$L = \varphi\ (p).$$

In the case of R_2, the difficulty is of the same kind. An order book for 35 000 m^3 which, according to the market trend, will be delivered within 12 months or within 24 months, must not automatically lead to the same quantity being ordered. In the former case, the deliveries during the next few months will be about sufficient to balance consumption; the quantity to be ordered should therefore be limited, on the understanding that it should be increased at the next campaign. In the other case, the monthly deliveries will rapidly become inadequate; all other things being equal,

it is therefore necessary to increase the quantity indicated by the formula.

In order to bring the formula closer to reality, it would be necessary to replace R_2 by the sum of the deliveries expected on the strength of earlier orders : r_2, r'_2, $r''_2 \ldots$, multiplied by a coefficient m which would depend on the rate of deliveries. One obtains then :

$$R_2 = mr_2 + m'r'_2 + m''r''_2 + \ldots = \Sigma\, m\, r_2.$$

Under these conditions, the classical formula could be found again but under a more complex form :

$$Q = K\,[P + St\,\varphi\,(p)] - \Sigma\, m\, r_2.$$

This rehabilitation of the conventional formula is not just a mathematical freak. It reflects the preoccupations of all those who have taken part in the search for the new solutions, and it has brought home to them the fact that what appeared to them, at the outset, as a revolutionary change in conventional methods was basically nothing but an adaptation of these methods to the realities of the market.

POSSIBILITIES OF GENERALIZING THE METHOD.

With the aid of the method set out here, it is possible to envisage new perspectives in the matter of replenishment of supplies. We do not claim it to be a discovery if we have shown that the conventional formula was not wholly applicable to the conditions of a given market. All those who are a little familiar with supply problems are aware of the need for differentiating the methods according to the quantity and nature of the purchases and a multitude of other factors, the listing of which would lead us too far.

It would seem, however, that these differentiations had the main object of moulding the market concerned in accordance with a more or less pre-determined and time-honoured « model ». Experience has shown that such methods of approach are not always successful. As we have already seen in France, and even in the European Economic Community, in respect of a great number of raw materials, the markets cannot be immediately expanded. The rates of expansion are of long-term character, whilst the terms of delivery sought by the buyer are incomparably shorter.

As a result of the study of conditions for wagon floor boards to which we have devoted ourselves, the market analysis has endowed the buyer, in these circumstances, with tools of higher quality. We believe that, in Europe just as in America, operational research is indispensable to the sound management of supplies. But the problems are not identical. We shall certainly benefit from the results already obtained by the Americans. But we shall not find, with them, all the material suitable for solving our own problems completely and satisfactorily. We should therefore add our own contribution, based on the characteristics of the home market, and we are fully convinced that studies of this kind will prove to be indispensable to buyers who are anxious to introduce more efficient management of supplies.

[**625** .172 (42)]

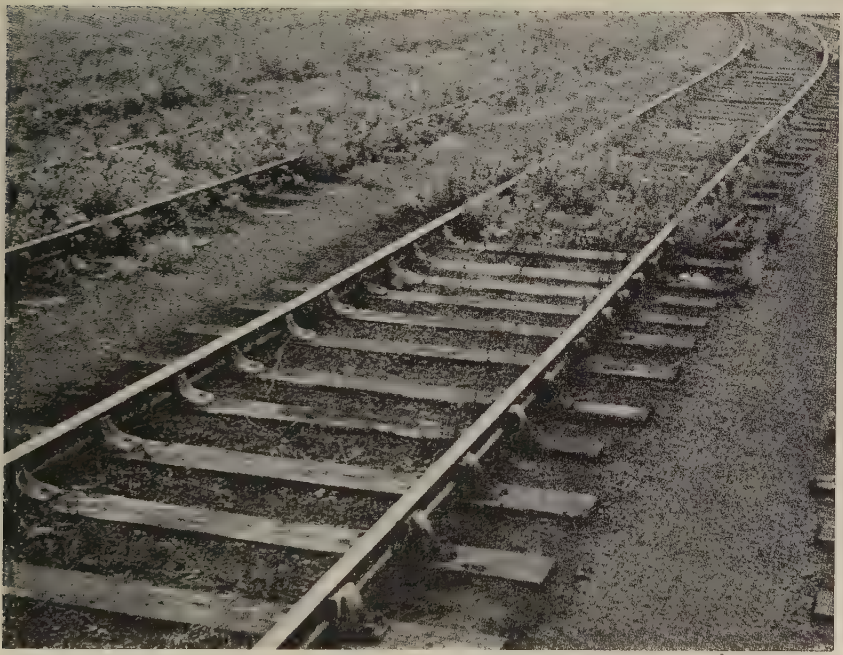
Progress in railway weed control.

A review on recent research on weed-killing, with particular reference to railway sites,

by Dr. G. S. Hartley.

Director of Research, Chesterford Park Research Station, Essex.

(From *The Railway Gazette*, October 16. 1959.)



Weed-infested tracks in Switzerland, showing section in foreground after treatment with simazin.

The major objects of hard ballast are to provide a foundation not movable under the influences of fluctuating pressure, wind, rain, vegetation and burrowing animals.

For the latter roles, it relies primarily on providing an inhospitable terrain for infant plants. Rapid drainage permits little moisture to be retained except at depths where light is minimal. But some plants compensate a high infant mortality with enormous fecundity, their seeds needing only a millionth chance to secure survival of the species. Plant life will establish itself in anything from the neglected chimney stack to the forgotten rain-butt. The hard-balast railway track is far from immune.

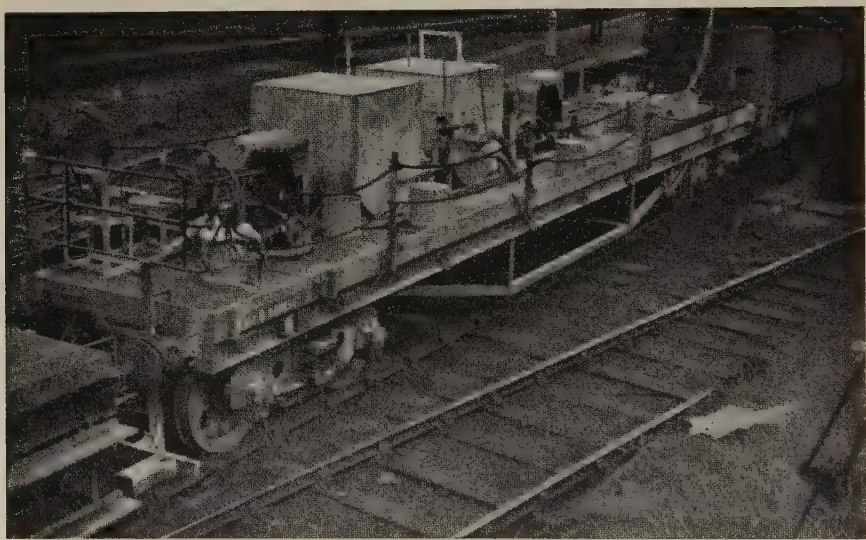
Means of clearance.

The factors which make new-laid track inhospitable to plant life make its removal by mechanical means difficult and inefficient. On the track itself and in the cesses, « gardening » is still practised despite its cost. Fire is sometimes an uninvited ally in dry areas, but too easily gets out of control. There remains the method of chemical attack — the use of plant poisons or herbicides.

Although the earliest seedlings and creeping perennials attain no great size, they assist the collection of airborne dust and this, together with their dead remains, leads to rapid build-up over the years. Maintenance becomes increasingly difficult, and eventually there is obstruction of ancillary moving gear and friction-reducing contamination of the rails. Rigorous exclusion of weeds from the beginning is now a practical possibility with new chemicals.

On tracks subject to a relatively low standard of maintenance, the demand on the herbicide is high because of the greater growth potential of the less clean ballast. The greatest density of weeds occurs in cesses and toe of the shoulder. To deal with this, modern mechanical sprayers incorporate means of delivering a high dosage of chemical in these places.

This article gives a brief review of the use of herbicides on railways, chemicals used, and methods of application. Reference will be made to methods which have not been applied to any extent in this country, but the main emphasis will be on methods applicable under British conditions of climate, population density, and social and legal standards.



Weed-spraying equipment mounted on standard rail bogie.

Because weed control on railway tracks is a world-wide requirement, the problem cannot be dealt with by one method in all areas. There is great variation in the relative importance of different factors — economic, climatic and biological. Availability of materials, including water; vigour of plant growth and speed and seasonality of its invasion; range of species of plants, not all best dealt with by the same chemicals; loss of chemical by leaching and wind erosion — all these factors influence our choice of method.

No standardisation in U.S.A.

In the U.S.A., where chemical control has had its longest and most advanced usage, different methods are adopted in different areas, and it is unlikely that uniformity will ever be reached. Only some of the American experience is applicable to our more limited climate and crowded conditions. Experience in Switzerland and Germany is more directly applicable.

Total herbicides of a rather crude type, applied in large dosages, have long been used on railway tracks. By comparison with other industrial sites — around fire vulnerable factories, oil stores and timber yards — the railway track is a better target for this weapon. It is accessible. Power and mechanical skill are available. Water, the cheapest convenient carrier of chemical, is necessarily in supply for other purposes. The width to be treated is simply related to the number of tracks : awkward corners difficult of access are few and unimportant. The surface is regular and well drained so that the chemical-bearing water runs in and not off.

Slow development.

Perhaps because the railways exercise a mechanical funition of great complexity and responsibility, the early starts in chemical methods of weed control has not kept up with recent developments which largely originated in agricultural work. Even the equipment for spraying is often rather primitive, a surprisingly large amount of the work being done by hand-operated, hand-propelled vehicles. Some aspects of mechanisation will be referred to later.

Until some 20 years ago, only four main types of chemical were in use, most extensively in the U.S.A. These were :

(i) *Crude oils.* These are used in massive dosage (100 gal./acre or more). They are as much physically as chemically toxic, grossly interfering with the all-important outer structure of plant tissues. They are reasonably effective and, because of their viscous nature and low solubility in water, persistent. They are economic only near to cheap sources of supply. They can be strengthened in effect and, therefore, reduced in dosage by addition of more toxic oil-soluble components such as high phenolic distillates (creosote) or, better, dinitro cresol. Such are called « fortified » oils.

(ii) *Compounds of arsenic.* Although actually essential to life in trace quantities, all ordinary compounds of this element are toxic to all forms of life if present in excessive amount. Crude ores have been used, but are difficult to apply uniformly. Arsenic is effective in producing lasting sterility but is highly toxic to animals. Straying of animals and blowing of contaminated dust on adjacent land led to heavy stock losses in the U.S.A.

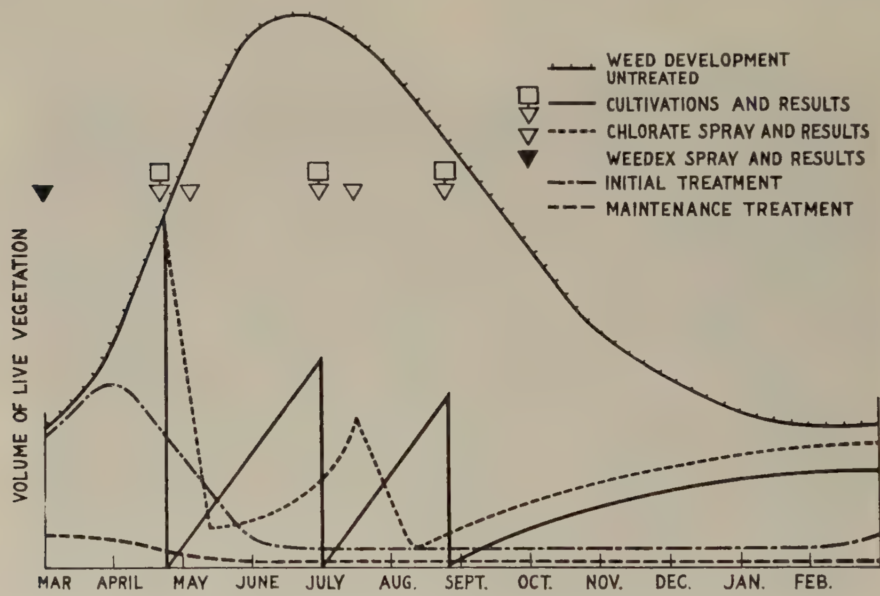
(iii) *Compounds of boron.* In particular, the soluble sodium tetraborate or « borax ». Boron, like arsenic, is an essential trace element, universally toxic in excess. It has the great advantage that toxic level is much lower in plants than in animals. It is still widely used, often in admixture with other chemicals to give it a wider « spectrum » of species controlled. Borates are soluble and easily leached from the soil, so their effect is not very persistent.

(iv) *Chlorates.* Generally, sodium chlorate is used. The compound is cheap, but high dosages (120-240 lb. per acre) are necessary. It is relatively harmless to animals but, being very soluble, it is rapidly leached out of the rooting zone in wet districts. It is, moreover, slowly reduced by organic matter in the soil to relatively harmless chloride, so that there is a chemical as well as physical source of loss. Chlorate, when dried in contact with organic matter, greatly increases the chances of ignition and the vigour of the resulting fire. Although almost universally « safetened » by addition of calcium chloride, it still increases fire risk. Chlorate has been the herbicide chiefly used on British Railways in the past.

In recent years many new and important organic chemical herbicides have been developed. The advance came during the war when two cheaply-produced chemicals, 2,

4-D and M.C.P.A., proved effective against most species of plants when applied in dosages as low as 1 lb. per acre or less, while having little effect on grasses. In countries of high agricultural efficiency, the greater part of the acreage of young cereals is treated with these chemicals.

They have been used on railways in the U.S.A., usually in admixture with sodium trichloracetate or sodium dichlorpropionate (dalapon), compounds which are particularly lethal to the grasses which 2, 4-D and M.C.P.A. alone would leave to flourish. Their great disadvantage, a particular drawback in intensively-farmed Britain, is that they are easily taken up by foliage and have an insidious effect on the growth of many plants at dosage levels far below those necessary to produce a satisfactory kill, where this is our object. When sprayed on railway tracks there is often sufficient downwind drift of fine spray to produce serious damage to susceptible adjoining crops — kale, sugarbeet and, especially, tomatoes. Already liable for considerable compensation for fire damage, the railways are naturally not anxious to incur another debit.



Graph showing results of spray treatments with Weedex (trade name of a simazin weed-killer).

Solubility and decomposition.

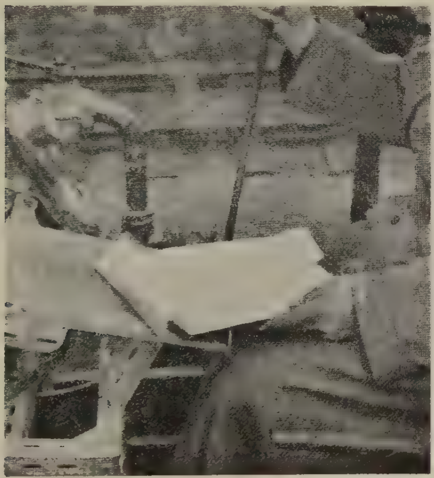
British rainfall is higher than that over a large part of the U.S.A. and consequently the very soluble herbicides, borate and chlorate, are not adequately persistent. The same applies to 2, 4-D and M.C.P.A. which, in moist conditions, are fairly rapidly decomposed by soil micro-organisms. Even with modern, relatively fast-running equipment, spraying is expensive and a disturbance to normal traffic. Infrequent application of a herbicide having persistent effect is therefore of the first importance.

The crowded agricultural and social conditions of Britain affect the problem in other ways. A higher standard of track maintenance is required and the drift dan-

ger is greater not only to agricultural crops but to populated property. With faster spray trains, accidental, spraying over bridge parapets on crowded roads is by no means negligible. It is better that this should occur with harmless chemicals, such as those recommended later in this article.

The success in agriculture of 2, 4-D and M.C.P.A. has led to intensive research to find new selective killers. Many interesting compounds have resulted, two of which under large-scale trials have shown great potential as total herbicides when used in adequate dosage. Both have interesting selective action at lower dosages. These are monuron and simazin. Both have close chemical relatives which are also active. Further developments are therefore probable. These compounds have important advantages for railway use.

They attack plants mainly through the root system. This probably largely results from their very low solubility in water so that the action of the very extensive water-absorbing roots is necessary to bring enough chemical into the interior of the plant. Whatever the reason, the fact that there is little foliage-action results in negligible effect of unavoidable drift.



Details of prototype spray train: (left) control lever to match spray output to speed; (right) matched shoulder and cess cover at 22 m.p.h.

Long-term effect.

The low solubility, combined with unusual resistance to bacterial attack, keeps the compounds effective in the rooting zone for a long time. Year-long effectiveness can be generally expected; sometimes longer. The very low solubility produces two disadvantages, which are comparatively unimportant. They are *a*) that the physiological action of the compounds is slow, and *b*) that they must be applied as suspensions, requiring agitation of the liquid to ensure even dosage.

With regard to their slow action, this is only a disadvantage, in proper use, while the staff responsible for weed control are acquiring experience and confidence. Once it is established by the workers' own experience that yearly sprayings with simazin will keep tracks substantially weed-free, it is not im-

portant that the few struggling invaders after last year's treatment should be seen to shrivel in the wake of the sprain train (*).

Prevention, not cure.

The object on railway tracks is to preserve a desert, not destroy a jungle. The more quickly and cheaply and the less frequently the operation for the former object can be carried out, the less often will it be necessary to adopt special measures with the second object in mind. Both of these new compounds are chemically compatible with the other rapid but more transient herbicides so that the latter can be used to accelerate the effect if densely-weedy derelict track has to be attacked.

As the compounds are slow in action and operate mainly through the root, they must be made to penetrate to the rooting zone at the time required. Early sprayings, before prolonged dry weather, are clearly desirable. It may even be found preferable to spray in late autumn or during open weather in winter. This basic difference between the new preventive treatments and the old killers of established weeds is illustrated in the graph.

The advantage of long-period persistent action will not be fully realised if the ballast is subjected to mechanical disturbance after application. Where a persistent herbicide is used, « gardening » is unnecessary. It is to be hoped, although it is at present too early to assess whether the hope can be realised, that preservation of a clean track from the beginning by these persistent herbicides will reduce the frequency with which costly mechanical track cleaning must be carried out.

Track at Springhead Goods Depot, North Eastern Region, British Railways: (left) treated; (right) untreated.

With regard to the disadvantage that these compounds must be used as suspensions, this does not seem a great obstacle. When one considers the complexity of efficient machinery necessary to carry huge loads of passengers and goods and the workshop and engineer resources which back up this service, the problem of stirring a liquid while spraying it can hardly be considered a difficult one.

Prototype sprayer.

It has been the privilege of the agricultural research station that I serve to make, in its own workshop, applying its agricul-

(*) No herbicide produces its full effect short of several days at best. The fortified oils produce extensive visible damage in a few hours.

tural spraying knowledge, — a prototype sprayer for the railways to deliver a regulated dosage of simazin powder suspended in water. This machine has already been described in this journal. It has sprayed at 20 m.p.h. delivering 80 gal. per acre and it would seem possible to improve on this, the problems to be overcome largely arising from use of an unspecifically-adapted means of locomotion. I look forward to the engineering of a streamlined durable unit.

The need for water is solely to carry the chemical conveniently and evenly to the track. It is not to wash in chemical. Even in the driest part of England, average daily rainfall is over 1 000 gal. per acre. It is evident, therefore, that we cannot possibly apply water to compete with one light shower. As we are using only a very low dosage of suspended chemical, the amount of water necessary is determined by spray-mechanics — enough to use sufficiently large drops to avoid serious unevenness resulting from wind-action without separating the drops to an extent which would interfere with even coverage.

Experience to date with both the new compounds referred to has shown us that simazin is the more suitable for railway use. Weight for weight, it is rather more persistent than monuron, particularly when used on ash ballast which tends to « absorb » the chemicals, i.e., to hold them in a state of reduced activity. It is also easier to suspend and to see after spraying. Neither compound has been as successful in arid climates as in temperate ones. In part, this is because the material is not adequately washed down to the deep rooting zone and evaporation losses are greater in consequence of more surface exposure at higher temperature. There is slight indication of a similar tendency between the wetter and drier parts of this country. I have mentioned that the compounds have several active relatives. A more soluble relative of simazin, called atrazine, may well prove to have advantage over simazin in drier eastern districts of Britain.

Chlorates and conductivity.

Modern railways make increasing use of electrical signalling and communication equipment. Chlorate solutions in water are inevitably highly conducting. They can cause direct trouble as a result of shorting and, as their action is corrosive on metals, indirect mechanical and electrical troubles. Their use on electrically-operated railways with conductor rails is even more undesirable. Even borates, though much less corrosive, have undesirable electrical conductivity. These factors increase the advantages of monuron and simazin. Suspensions of these insoluble non-electrolytes in water contribute less to the conductivity of the water than the impurities normally present in ordinary sources of supply.

There is ample evidence to support the view that a spray programme, technically sound in regard to choice of chemical and means of application, could give a much higher standard of weed control across the whole section of the track than has been hitherto possible. The treatment will replace the present use of non-persistent herbicides and will dispense with the aid of manual methods, the practice of which is antagonistic to the effectiveness of a persistent herbicide. The final result will be the maintenance of a cleaner track at lower cost.

[656 .2 (52)]

A new epoch in Japanese National Railways,

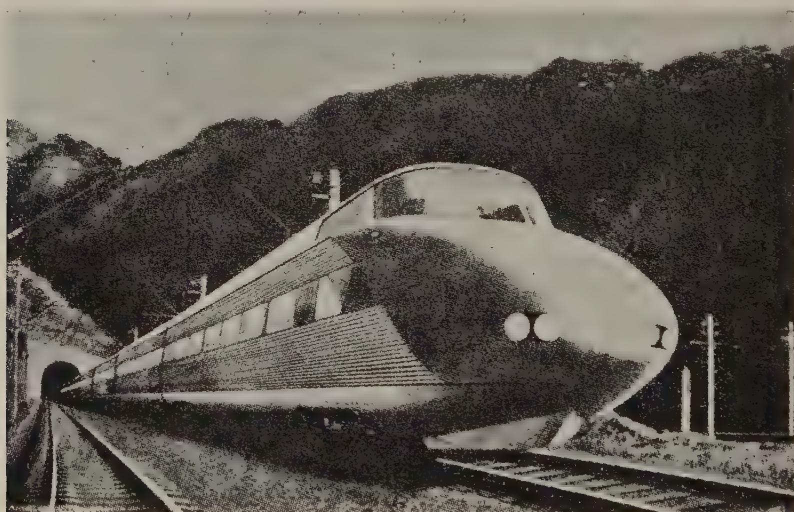
by Shinji SOGO,

President, Japanese National Railways.

(*Indian Railways*, August 1959.)

In area a small country but in industry one of the big few, Japan presents a model to under-developed countries, especially of Asia. The story of the stupendous rise she has made since she started reconstructing her war-torn economy in 1949, is retold in this impressive article devoted to Japan's transport, especially her National Railways. Indeed, not only does Japan compare favourably with other industrially advanced countries of Europe, in some cases she has actually done better than them, as is borne out by figures.

Japan is a sea-girt country consisting of four major islands (Hokkaido, Honshu, Shikoku and Kyushu) which stretch from north to south almost in a straight row. The area of the land is merely 368 000 sq. km but since each of the islands is traversed by a longitudinal range of mountains from which swift streams meander their way to the ocean, less than 20 % of the land is flat. Naturally, the population centres have developed in the delta areas along the sea coast, and the coastline is dotted with a succession of cities.



A concept of the super-express on the new Tokaido Line.

The population of Japan is approximately 90 million and its density is 241 people per square kilometre, but when only flat land is considered, the density would undoubtedly rank amongst the highest in the world, presenting a problem in the nation's transport policy.

Its geographical features and climate also have a great effect on transport in Japan. The northern part of Honshu and all of Hokkaido is covered with snow during the winter, and in summer and autumn, the southern part of the country, especially, is threatened by typhoons and floods which have been causing considerable damage.

As may be inferred from the topography of the country, inland transport has mostly developed along the sea coast, and railways (mainly the Japanese National Railways) have formed a loop around each of these islands, linking the cities along the seaboard. Till recently, road transport has developed as an auxiliary to rail transport, with their activities centring in large city areas. Initially, the greater part of these road services was provided by private companies, but JNR, too, has come to undertake road transport, as a means of improving its services through co-ordinated rail-road transport, and at present, the network of this service extends to about 10 000 km.

Before the last war, marine transport played an important role in long-distance mass transport of passengers and freight, but on account of heavy damage to shipping and port facilities during the war as well as the slow pace of modernization in the relative installations, coastal shipping has not yet recovered to its pre-war level, and as a result, a large share of coastwise cargo transport is now being borne by the railway.

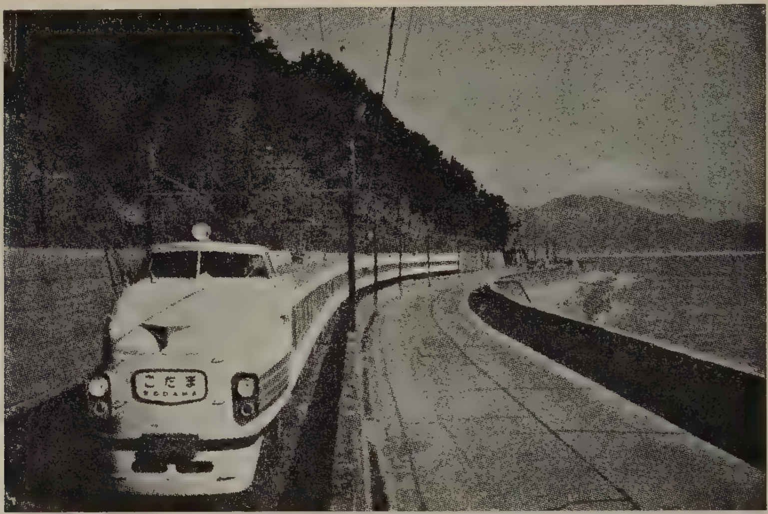
Since the restoration of peace in 1945, the overall volume of traffic has come to increase very rapidly in line with the growth in population and recovery in industry. In 1949, when the nation began to regain its post-war economic stability, the total volume of traffic carried by the various carriers of the nation amounted to 8 826 million passengers and 434 million tons of freight, while in 1957 these figures rose to 15 625 million passengers and 1 032 million tons of freight, which are increases of about 77 % for passengers and 230 % for freight — and this trend is most likely to continue in the future.

The important role played by the railway, especially JNR, can be inferred from the following table. Volume of Traffic Handled by Different Carriers (1957).

A five-ton container being handled by a fork lift.

Passenger traffic :

	Passenger-km (100 millions).	Ratio.
National Railways	1 012	54 %
Private Railways	308	16 %
Tramways	196	10 %
Road Transport	350	19 %
Marine Transport	9	1 %
Air Transport	3	0 %



The « Kodama », now in service on the Tokaido Line, the fastest train on JNR.

Freight traffic :

	Ton-km (100 millions).	Ratio.
National Railways	482	47 %
Private Railways	8	1 %
Road Transport	111	11 %
Marine Transport	290	29 %
Barges	125	12 %

With the recent development in domestic automobile manufacturing industries and improvement in roads, road traffic has come to expand extremely rapidly, affecting the overall transport picture of the nation. More and more short and middle distance sightseeing passengers and short distance freight as well as high class merchandise, and such perishable foodstuff as fresh fish and fruits are being diverted to motor carriers; and besides, rapid development is also being made in short and middle distance transport by private motor vehicles. However, a great difference is noticeable when the situation is compared with that in U.S.A. According to the 1956 edition of I.C.C. statistics, the percentages of intercity traffic in U.S.A. resorting to motor vehicles were 92 % with respect to passengers and 18 % for freight, while in Japan (including intracity traffic), the former was 20 % and the latter 10 % for the year.

On account of economic, topographic and climatic restrictions in road building and improvement in Japan, and in view of the rapid increase in the demand for rail transport as well as its capability for mass transport at low cost, we feel that there will be very little change in the foreseeable future in the share to be borne by the railway. Of course, this is on the grounds that the railway will continue to modernize and rationalize its service by containerization, mechanization of goods handling, curtailment of transport time and other improved methods.

The results attained by JNR in rationalized operation and cost of transport compare favourably with any railway in the world; in fact, it may even be proud of itself in this respect.

Since the railway enterprise involves huge amounts of investments in permanent way facilities and rolling stock, it goes without saying that attainment of a high rate of capital turnover through improved turnround of rolling stock and utilization of tracks should be the basic economic aim in railway operation. The average number of trains operated daily per main track kilometre on JNR was 46 trains in 1956, whereas this was 36 trains on the German Federal Railway, 29 trains on the British Railways and 19 trains on the French National Railways. In Japan, as many as 242 trains are operated two ways a day on a section between Maibara and Hikone on the Tokaido Line, while only 183 trains are operated between Etampes and Toury in France and 65 trains between Cleveland and Buffalo on the New York Central System in U.S.A.

Car retarders at Shintsurumi Marshalling Yard.

The « Kodama » (Echo) of JNR runs between Tokyo and Osaka on the narrow gauge at the maximum speed of 110 km/h. As for the maximum train speeds of railways with broader gauge in Europe and U.S.A., that for the « Helvetia » of the German Federal Railway (Hambourg-Basel) is 140 km/h, for the « Oiseau-Bleu » (Paris-Brussels) of the French National Railways 140 km/h and for the « Broadway Limited » (New York-Chicago) of the Pennsylvania Railroad in U.S.A. 153 km/h that is, these trains on the wider gauge are only a little faster than the Japanese trains. Besides, we hear that there is less vibration on the « Kodama ».

On JNR, as many as 4 260 000 passengers were carried per main track kilometre in a year, whereas this was only 950 000 passengers on the German Federal Railway, 530 000 passengers on the French National Railways and 590 000 passengers for the British Railways. Likewise, the tonnage carried per main track kilometre amounted to 2 040 000 tons on JNR, while it was merely 1 290 000 tons on the German Federal Railway, 940 000 tons on the French National Railways and 660 000 tons on the British Railways.

The average passenger car and wagon kilometreage per day on JNR was 281 km and 118 km, respectively, while the cor-

View of Shintsurumi Marshalling Yard near Tokyo, which handles an average of 5 600 cars a day.

responding figures on Class I Railroads in U.S.A. were only 249 and 69 km, on the German Federal Railway 215 and 56 km and on the French National Railways 193 and 42 km, respectively.

These comparisons serve to show that tracks and rolling stock are utilized to the highest degree on JNR. As for the number of passengers carried per car and the tonnage per wagon, the results were as follows, provided that the size of the cars used abroad are converted into the same units as are used on JNR.

Passengers per car: JNR 65, German Federal Railway 35, French National Railways 32, Class I Railroads in U.S.A. 20.

Tonnage per car: JNR 10.5, German Federal Railway 6.8, French National Railways 6.6, British Railways 6.0, Class I Railroads in U.S.A. 6.6.

Incidentally, it might also be of interest to compare the fares and rates, that is, the average receipt per passenger-kilometre and ton-kilometre of these railways. They were as follows, showing the low level of JNR.

	Receipt per passenger-km (in yen).	Receipt per ton-km (in yen).
JNR	1.51	3.06
West Germany	3.30	6.29
France	5.20	6.46
Great Britain	3.78	8.16
Class I Railroads, U.S.A.	5.83	3.38

Container train of 24 wagons to be put into service between Tokyo and Osaka in November this year.

The Tokaido Line problem.

The large cities in Japan, with population over 500 000, such as Tokyo, Yokohama, Nagoya, Osaka and Kobe, are mostly located along the Pacific coast in the central part of Honshu, and in between these cities, are found many middle-sized and smaller ones. The total population in this region numbers 36 million, which comprises about 40 % of the national population. There are four major industrial areas in Japan — the Tokyo-Yoko-

Note. — 1. The comparisons under this heading were based on the 1956 edition of « International Railway Statistics » published by the International Union of Railways (U.I.C.).

2. 75.6 Yens = one rupee.

JNR's ferry, « Towada-maru », now operating between Honsbu and Hokkaido: gross tonnage 6 148 tons, carrying capacity 1 470 passengers and 18 wagons, speed 14.5 knots.

hama area, the Nagoya area, the Osaka-Kobe area and the Northern Kyushu area — of which, the industrial output of the first three areas mentioned constitutes over 60 % of the total output of the nation. From these facts one can readily realize the vital importance of the Tokaido Line which links these areas shouldering the burden of transport in the whole region. In other words, this line between Tokyo and Osaka is only 550 km in length, or merely 2.9 % of JNR's total route kilometreage, but on the other hand, the volume of traffic handled over this line in 1957 amounted to 24 100 million passenger-km and 11 000 ton-km, constituting 24 % and 23 %, respectively, of JNR's total.

At present, from 60 to 80 passenger trains and 50 to 60 freight trains, or a total of 110 to 140 trains are being operated one way a day on this line. In addition, the rate of growth in both passenger and freight traffic on this line has been much higher than on other lines. Whilst JNR has been reinforcing the facilities on this line to meet this situation, including the electrification of the whole line in 1956, and thus attaining the aforementioned record — the highest efficiency in the world for a narrow gauge railway — the transport demand on the line is outpacing its capacity, making it necessary for JNR to take drastic countermeasures. In sizing up the volume of traffic expected on this line in the future, detailed studies would, of course, have to be made in the expected rate of growth in gross national product, the transport demand to be created and the share to be borne by other modes of transport, especially, the effects of motor transport. According to these studies, at the minimum, JNR will have to carry in 1975, about twice as many passengers and 2.2 times as much freight as it did in 1956.

Upon examining the present capacity of the Tokaido Line in this context, we find that since trains of different speeds are operated on the same track, 120 trains one way a day is the practical limit of the line, although it is double-tracked. As

Side view of « Kodama » while she runs between Tokyo and Osaka.

any excess over this figure would have to be attained with much difficulty, it is feared that by 1961 or 1962 there will be no more room to operate additional trains on the line.

Should such a situation occur, the Tokaido Line would become a bottleneck in the flow of traffic between northern and southern Japan. This would not only have a paralysing effect on the whole of JNR's transport system, but on the industrial and cultural progress of the nation as well.

These very facts point to the urgent necessity of constructing another line in addition to the one in existence, and accordingly, we have decided to construct a new double-track Tokaido Line. This will be a fresh start for us, a start towards the goal of making our system the most modern in the world, and with this in mind, we have been carrying out necessary research work for the last several years so that the highest level of technology and methods available on a worldwide basis would be incorporated in the construction and operation of this new line.

Upon obtaining the final approval of the National Diet in March, this year, the ground breaking ceremony for the project was held in April, from which the new fiscal year commences. The project is expected to be completed in about five years at a cost of approximately 172 500 million yen (479 million dollars), including the cost of the necessary rolling stock.

Separate route and standard gauge.

The route to be followed by the new line — whether it should be parallel to or separate from the present one — was one of the problems that had to be settled first, and the matter was carefully weighed. If the new line were to be constructed parallel to the present one, much more time and money would be required in the acquisition of right-of-way in the many urban areas through which the line would be passing as well as in improving the curves and station facilities *en route*. Besides, it would also become necessary to get rid of the numerous level crossings, 1 060 in all, in order to attain high-speed operation. It was, therefore, decided to have a separately routed line. Since the shortest possible route will be followed in this case, although it means more bridges and tunnels, the line would be shortened to about 500 km, which is about 50 km less than the present line (553.7 km). When completed, we intend to make a discrimination in the usage of the new and old lines, the former, as a long-distance, high-speed railway (for high-speed passenger and freight trains), and the latter, as a low-speed railway for short distance traffic (suburban trains, local passenger trains and ordinary freight trains). In both, the frequency of trains will be raised and the travelling and delivery time shortened for the convenience and benefit of the general public.

The next problem was about the gauge to be adopted. Heretofore, JNR has adhered to the narrow 1.067 m gauge, but by adopting the standard gauge, not only would it be possible to increase the carrying capacity by 30 %, it would also be possible to attain higher train speeds and a higher frequency of train operation. This is because freight trains cannot be operated at high speeds on the narrow gauge, and the wide gap between the speeds of passenger and freight trains, naturally tends to decrease the number of trains that can be operated. At present, the maximum speeds of fast express trains in Europe and U.S.A. is about 150 km/h, and the average speed about 100 km/h, but on the new Tokaido Line it would be possible to operate trains safely and with comfort to passengers at the maximum speed of 250 km/h and the average speed of 170 km/h. Of course, to attain this, latest techniques will be adopted, grades and curves reduced, and the lines made free of level crossings. In view of the wider tracks, larger rolling stock, higher frequency of train operation and higher speeds attainable, the transport potential of the standard gauge would be much higher than that of the narrow gauge, enabling it to meet transport demands for a longer period of time in the future.

Passenger and freight services.

After due consideration of the transport capacity, operational safety, comfort to passengers and economy, and after a comparative study between JNR and other modes of transport, in particular, motor transport, the conclusion was reached that it would be most beneficial to the national economy if a new system of co-ordinated rail-road transport would be adopted so that rail and road transport would each carry out its functions in the sphere of transport activities most suited to it. From this standpoint, the standard gauge, which would enable the adoption of the so-called « piggyback » system, was considered to be most suitable for the new line.

On the present Tokaido Line the electric multiple unit express « Kodama », the fastest train in the world for narrow gauge, is covering the 550-km distance between Tokyo and Osaka in 6 h 50 min (maximum speed 110 km/h), and the modern design of the cars and their superior performance have already earned this train a very high reputation. Yet, on the new line, the economic A.C. electrification system will be adopted, wider tracks and larger cars used, and super-express multiple unit electric trains will be able to link Tokyo and Osaka in less than half the time required today, that is, in 3 h at the maximum speed of 250 km/h. The latest techniques including those on vibration and sound proofing and air-conditioning, will be adopted on these trains to enhance riding comfort, making them superlative to trains now in operation.

During these recent years, road transport has developed very rapidly with the improvement in roads, and the rate of growth in traffic volume resorting to motor carriers is, by far, surpassing that of the railway. Despite this growth in road traffic, the absolute volume carried by rail is much higher in Japan as well as in other countries in Europe and U.S.A., and especially with regards to long-distance mass transport, it is obvious that rail transport would be cheaper and faster.

Container and piggy system.

The weak point of the railway in its passenger service is that it cannot provide door-to-door transport but the effects of this shortcoming show much more markedly in freight traffic. While the passenger may change to another means of transport at will on his own feet, this would not be the case with freight, which requires repetitive loading and unloading — from door to motor vehicle — from motor vehicle to goods wagon — and reverse. On account of this complexity, much time and energy is lost and damage to goods becomes unavoidable despite the large sum spent in packing, which might even amount to several times that of the railway freight rate itself.

This, however, can be overcome to a great extent by making use of the mobility of motor vehicles, and for the purpose, such modern and co-ordinated rail-road freight transport methods as the container and piggyback system will be adopted on the new line, so that in effect, the same door-to-door service can be provided. In carrying this plan out, studies will be made from various angles, according to local conditions and types of goods, so that a system most befitting the demand of the times may be adopted. In addition, the time required for freight transport will also be greatly curtailed on the new line — high speed freight trains will link Tokyo and Osaka in 5 1/2 h.

Technically, the new trunk line aims at achieving the highest level attainable in railway engineering and in the operational side, too, the latest methods will be adopted, which, it is hoped, will become epochmaking in the railway world. The twentieth century has given birth to new modes of transport — motor vehicles and aircraft — but with the birth of this new Tokaido Line, we firmly believe that the railway which came into existence in the nineteenth century will be able to pave its way for a great stride ahead as a newly-born railway most worthy of meeting the demands of a new age.

It is our important mission, and our greatest hope, to contribute to the economic and cultural progress of the world by building a railway which we can proudly pass on to posterity as the most modern means of transport in the twentieth century.

[**621** .137 (47)]

A few notes concerning the Russian « Automaton Drive » and the economic drive,

by N. B. Van Albada, Engineer.

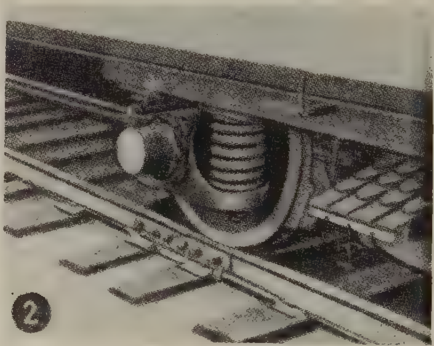
(*Spoor- en Tramwegen*, 1st January 1959.)

« In a black evening and bad weather, from the platform at « km 139 » near Besymjanka station, an electric train leaves. The unending rails fly towards it; headlamps illuminate the track.

» The driver Fjodor Sjapko has driven trains in all kinds of weather, but this time it is a special run. For the first time in his life, he plays the role of a spectator on his locomotive. Everything is controlled by a special automatic device which fulfils its task in the most exact manner. The equipment reacts in time to the instructions of the automatic signals and reduces the speed whenever necessary. Shortly before arriving at Zoebtajaninofka, the « automaton driver » selects the instant at which a brake application should be made, reduces the speed, and makes a shockless stop alongside the platform. »

These are the opening expressions of the enthusiastic description of the apparatus which has been described briefly in « Spoorwegtransport ».

1



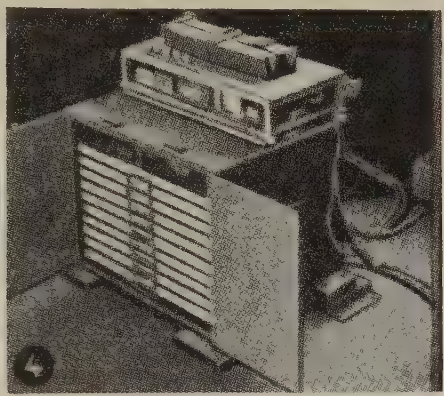
2

During the trial run, sets of curves have been recorded with an oscillograph.

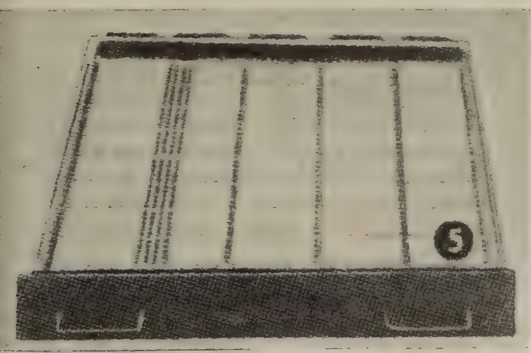
Photographs (fig. 1) show the table at which by pressing a button, the driver starts up the equipment. Figures 2 and 3 show the recorder fitted on an axle box which gives the speed and the distance travelled. The operational instruction sheet (fig. 4) contains data relating to the gradients and other known conditions. The drawer 5 contains the starting and braking characteristics and belongs to the computer above it seen in figure 6. The driver (fig. 7) is still responsible for watching the track and for the time being for supervising the proper working of the « automaton driver ».

The graphs of figure 8 give the speed as a function of the distance run. In the first part of the diagram, the starting curves are drawn in, for which the difference between t_w and t_p, i.e. the real time and the programme time, is kept below 1.5 sec. The curves of the second part give the

curves derived for a difference of 2.56 km/h. The third part shows how the maximum speed is maintained between two limits and the fourth part gives the braking curves. The heavy line which goes across all five parts indicates the selected speed.



The speed curves recorded in practice are shown in figure 9 which also gives the time-distance travelled curves. The full line is the calculated curve. The two others correspond to trial trains; they show at



the end of the run, the respective application of a permanent and of a temporary speed restriction. In addition, they indicate in a clear manner the lengths and gradients of the track.

Finally (fig. 10) represents the scheme of functioning.

There is already in existence a stationary machine (fig. 11), which calculates the relation between the journey time, the speed, and the distance travelled. It does it with a degree of inaccuracy of less than ± 1 % and works on the equation :

$$\frac{d^2s}{dt^2} = c\ [F\ (v) - w - b \pm i]$$

in which $\frac{d^2s}{dt^2}$ is the acceleration, F (v) the tractive effort :

w the resistance to forward motion;

b the braking force, and

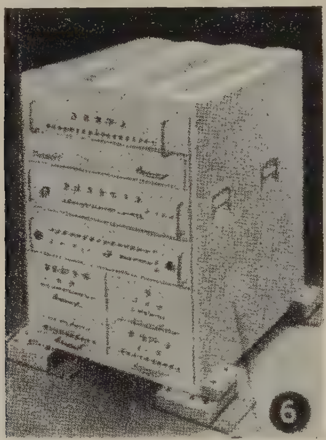
i the resistance due to the gradients and curves, all the values being expressed in kg/t;

c is the acceleration for an accelerating force of 1 kg/t.

The factor w is not a constant but a magnitude which varies with the speed and which depends again on the kind of rolling stock making up the train and the atmospheric conditions.

The « automaton drive » resolves the differential equation of the movement in

the same manner as the stationary machine. It determines experimentally the magnitude w. After a test run has been made, it compares the actual time with the calculated time and the calculated time for the next section is compared with the programmed time. The machine continues to make these trials until the difference between the programmed journey time and that calculated changes sign; it then turns over to the optimum calculated diagram and so determine the instants at which to cut off the traction and apply the brakes. The stop of the train is done with an accuracy of within 4 to 5 m.



One of the organs shown in the scheme of working of figure 10 is the logical selection apparatus which determines the curves to be applied and the maximum speed to be attained. We will not describe how this is achieved. We can conclude from figure 9 that the second echelon of increase of the speed, probably the coupling of the traction motors in parallel of the motive power unit employed, has not been used; this probably was because the journey time did not demand it.

As an advantage of the « automaton drive », in the first place the better observation of the time table is quoted. The irregular profile of the track requires the driver to make a careful choice of the coupling to be used. A good driver can reduce the journey time by 5 to 7 % whilst a less efficient driver does not know how « to keep time » with the same train. In addition, a further claim is made for a saving in current or fuel oil with Diesel locomotives, and it is thought it will also be possible to progress further in this direction when it and the following trains are linked together by wireless and that without causing unnecessary stops the « automaton drive » will maintain between these trains an adequate distance.

The trial equipment has been developed under the direction of the Engineer N. S. NIKOLAJEW.

So far the Russian description has been followed.

* * *

If we admit that such apparatus can be mass produced at prices which will permit its installation on motor vehicles, it then becomes interesting to see the applications that could be made thereof in Holland.

We imagine to begin with trains running without a driver on our principal electrified line, that between The Hague and Rotterdam. A guard would be retained provisionally and would be required

should the equipment fail — this would automatically cause the train to come to rest — to cease acting as guard and become again the driver. Before running into a dead-end station, as a matter of precaution, he would have to be in the driving position. There would be no danger so long as the « automaton drive » obeyed the signals in a totally positive way. One thing, however, remains disturbing : the « automaton drive » does not see unexpected obstacles. A driver who sees a motor car stopped on a level crossing, will do everything possible to stop in time. Even if in this he is not successful in all circumstances, the fact of accepting with full knowledge that an « automaton driver » drives the train and cannot perceive an obstruction would deserve very full consideration.

Our drivers have not much difficulty in respecting the timing of the passenger trains; it is undesirable to arrive too soon or too late, and the habit of good driving is quickly learnt, the more so as the trains on a given line generally follow the same timing and as the margin between the speed to be worked to and the maximum allowed speed is small. Similarly with goods trains, the difficulties are not great; had it not been so, it would have been necessary to lay down much longer passing times in the timetable sheets. It is more difficult to prevent trains stopping at signals at danger. This depends sometimes upon train movements in other directions or through dealing with level crossings and in this case, the « automaton drive » will not solve it. To warn a train that it has to slow down because another slow train is in front would result in many useless stops, but it is not necessary for this to remove the whole work from the driver's hands.

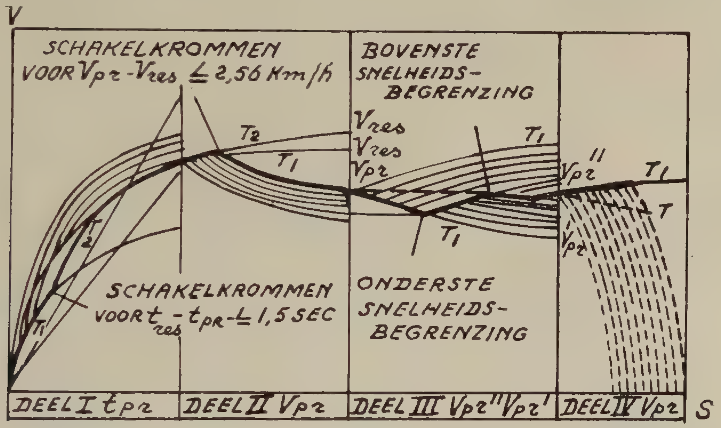


Fig. 8.

N. B. — Schakelkrommen voor = starting curves for. — Bovenste snelheidsbegrenzing = upper speed limit. — Onderste snelheidsbegrenzing = lower speed limit.

The automatic driving offers greater prospects from the point of saving of current or Diesel fuel. There are drivers who work economically and others who force themselves to attain the maximum speed as quickly as possible which is not economical, especially in the case of stopping trains, if the train is braked immediately after reaching the maximum speed. An « automaton drive » which watches all the time to see that the best coupling is being used has then real value.

Let us re-examine the problem. On a level run, it is an advantage from the point of view of the train resistance to run as long as possible at a constant maximum speed, a speed which for a given journey time, should be the lowest possible. It is found from the relation :

$$t = \int_{s_2}^{s_1} \frac{1}{v}\, ds$$

(t = time, s = distance and v = speed). The work to be done is proportional to

$\int_{s_2}^{s_1} w ds$ or w, in which w = the train resistance is made up for the small part of a constant quantity and for a large part of a quantity proportional to v^2. This rule however is to be corrected when in a certain range of speed the output of the electrical equipment is low. This is the case for example for an electric vehicle which is run on resistances and also when there is need of heavy currents at certain places where the voltage of the overhead wire is low.

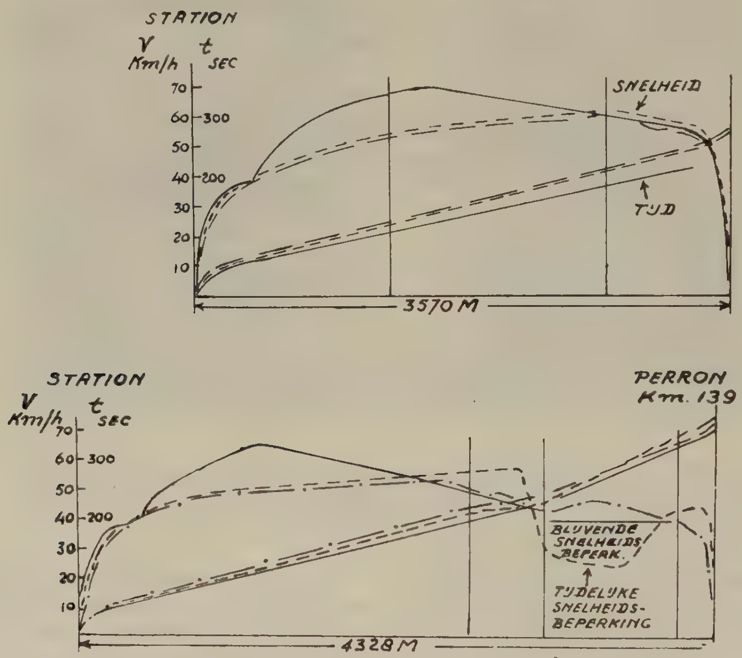


Fig. 9.

N. B. — Snelheid = speed. — Tijd = time. — Blijvende snelheidsbeperking = permanent speed restriction. — Tijdelijke snelheidsbeperking = temporary speed restriction.

If the speed required is such that with an economical running notch the speed becomes too high, it may be to a certain extent more-profitable to select a higher speed and then let the train coast rather than to make a succession of switching in and out to keep the speed constant. It could be more effective too for short journeys to avoid parallel coupling and run in shunted series coupling. However, too

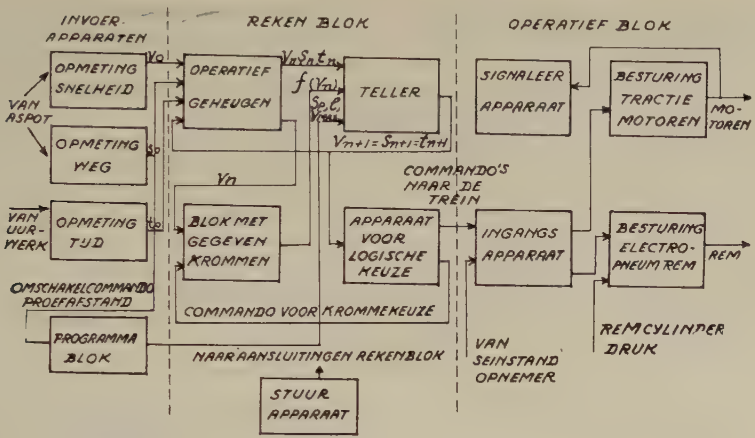


Fig. 10.

Explanation of the Dutch expressions :

Invoerapparaten = apparatus supplying the data. — Rekenblok = computer block. — Operatieblok = operational block. — Van aspot = from the axle box. — Van uurwerk = of the chronometer. — Omschakelcommando proefafstand = drive for the test runs. — Programmablok = programme making block. — Operatief geheugen = operational instruction sheet. — Opmeting snelheid = speed measurement. — Opmeting weg = distance run measurement. — Opmeting tijd = time measurement. — Teller = calculator. — Blok met gegeven krommen = block with predetermined curves. — Apparaat voor logische keuze = apparatus for logical selection. — Commando voor krommenkeuze = control of the selection of the curves. — Naar aansluitingen rekenblok = towards the connection with the computer block. — Stuurapparaat = driving apparatus. — Commando's naar de trein = controls towards the train. — Signaleer apparaat = signalling apparatus. — Besturing tractiemotoren = traction motors control gear. — Motoren = motors. — Ingangs apparaat = reception apparatus. — Besturing electropneum. rem = electro-pneumatic brake operating gear. — Rem = brake. — Van seinstand opnemer = from the recorder of the position of the signals. — Remcylinderdruk = pressure in the brake cylinder.

many illusions must not be had on this subject : it is always necessary to pass through the resistances before coming into series coupling and the losses in the resistances when going in to parallel coupling are not great, the operation only taking about twenty seconds.

Over a hilly route, it is an advantage to regulate the speed in such a manner that the train would get to the bottom of a slope without braking. It would then be necessary to get to the top of the up gradient at low speed, as low as the timetable would allow. If the up gradient is a heavy one, so that at full power speed falls, it is necessary to see that it is run onto with sufficient speed.

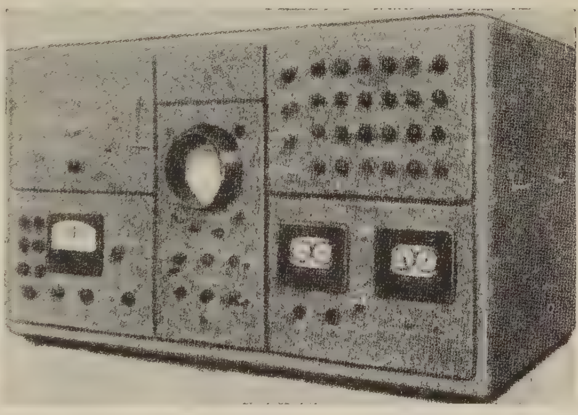


Fig. 11.

An « automaton drive » — like a driver driving economically — first of all should select the speed to be attained, and then for a run on the level approach it in such fashion that the distance-speed curve does not show too many and undesirable fluctuations, whilst remaining within the range of maximum speed and authorised journey time, a margin which is not great in our country. To the extent that the up gradients cannot be met by adjusting the power of the locomotive, their influence has to be calculated. In this case, the computor has the advantage over a driver who is able only to estimate it. The base on which the calculation rests, always remains the realisation of a ceiling speed, as uniform as possible without exaggerated braking.

Outside the mathematical principle, there are still some difficulties to be resolved in automatic driving. The distance-speed recorder must be able to adapt itself to the wear of the tyres. Slipping may upset it, especially during braking.

However this be — by « automaton » or not — economical driving is worthy of attention.

[385 (09 .2]

OBITUARY.

Octave HENRY-GRÉARD,

Former Manager of the Paris-Orleans Railway Company.

Former General Manager of the P.O.-Midi Joint Working.

Former Member of the Permanent Commission of the International Railway Congress Association.

One of the most striking personalities of the French Railways died on the 23rd December last, at the age of 79 years: M. Octave HENRY-GRÉARD, former Manager of the Paris-Orleans Railway Company, former General Manager of the P.O.-Midi Joint Working, and former Member of the Permanent Commission of our Association.

We give below the outline of the eminent career of our former colleague, published in the *Revue Générale des Chemins de fer.*

He left the Polytechnic School in 1901 as Mining Engineer, and was appointed engineer in the « Corps des Mines » in October 1905, he devoted five years to service in the Mines in the North Region. On the 25th November 1910, he joined the Orleans Railway Company as an engineer in the Central Operating Department; he was appointed Assistant Traffic Manager of this Company in October 1912.

During the 1914 war, he was chosen by the Army Staff Office to carry out a delicate mission in Russia between June 1916 and February 1917, in connection with the organisation of transport in the country and in the military zone. On this occasion, he was appointed « Chevalier de la Légion d'Honneur », Military grade, as a fitting recompense for the work he carried out in a difficult post.

When he returned to the P.O. Company, he was appointed in turn Traffic Manager, Assistant General Manager and in January 1930 General Manager. The results obtained under his management, characterised in particular in the case

of the P.O. by one of the best operating coefficients obtained by the French railways, showed that he knew how to make the railway profit by his eminent ability as regards organisation, method, and economy, as well as his great authority.

He was appointed Commandeur of the Légion d'Honneur in July 1933.

When the P.O. and Midi Railways were amalgamated on the 1st January 1934, he was the natural choice for General Manager of the P.O.-Midi Joint Company. Here again he carried through the difficult task of realising an effective amalgamation of the two former companies and making them into a coherent organisation that would work reliably.

Thanks to his great authority and gift for organisation and leadership, the objective was attained and at the beginning of 1938, he was able to hand over to the S.N.C.F. an efficient railway system that could serve as a model on many points.

Put no the retirement list at this time at his own request, he was appointed Honorary General Manager of the P.O.-Midi, and still continued to lead an active life. His administrative ability, his well proved good sense, his great experience and his unanimously recognised competence in all transport matters led him to be chosen for various important positions in which, right up to the end, he carried out his work with his usual activity and conscientiousness. For example, he was President of the General Light Railways Company, then Honorary President and Administrator of the same Company, President of the Damas-Hama Railway and Extensions, of the Tangier to Fez Railway, of the East Morocco Railways. He also took part in the work of the Transport Office of the Paris Region.

He leaves behind the memory of a man who, together with outstanding technical qualities, had other admirable personal characteristics, perfect dignity, scrupulous loyalty, great kindliness and unruffled humour. He was able to gain and retain the affection. esteem and respect of all those with whom he worked, collaborated and directed.

M. HENRY-GRÉARD was elected a Member of the Permanent Commission of our Association in 1930. His work on behalf of the Association however dates back as far as the Rome Congress (1922), at which he was the Reporter for Question XIII : Net cost. - Rates. He represented the Paris-Orleans Company at the London Congress (1925) and Madrid Congress (1930). He took part in the Enlarged Meeting of the Permanent Commission at Brussels in 1935 and at the Paris Congress in 1937, where he was also a Member of the Local Organisation Committee. He resigned his mandate in 1938.

His courteous affability and his great simplicity gained him the sympathy and esteem of all his colleagues on the Permanent Commission.

We offer his family our sincerest condolences.

The Executive Committee.

[385 (06 .111]

OFFICIAL INFORMATION

ISSUED BY THE

PERMANENT COMMISSION

OF THE

International Railway Congress Association.

Enlarged Meeting of the Permanent Commission at Brussels (27th to 29th June, 1960).

FINAL SUMMARIES adopted at the Enlarged Meeting of the Permanent Commission of the International Railway Congress Association (Brussels, June 1960).

1st SECTION : Way and Works.

QUESTION 1.

The effect of electric traction on signalling and communication circuits, in particular reference to the means of overcoming interference, to provide safety and good communications.

SUMMARIES.

« 1. It is the general opinion of the « Administrations that interference be- « tween the substation power feeder « lines and the telecommunications and « signalling circuits does not present any « special problem.

« 2. At D.C. substations, transfor- « mer-rectifier sets of the mercury va- « pour type are now in virtually general « use. Most of the Administrations use « six-phase or twelve-phase rectifiers. « Filters designed to reduce harmonics « with rectified current are not often « used when the circuits which might « be affected are cabled.

« The equipment of A.C. substations « depends on the frequency. The solu- « tions adopted may comprise trans- « formers only, or rotary sets.

« In both A.C. and D.C. cases the « feeders are protected by ultra-high « speed circuit breakers. Automatic re- « closure is often used, with or with- « out automatic testing of the insulation « of the catenary.

« 3. The problem of interference phe- « nomena between the traction contact

« lines and the telecommunications and « signalling circuits (which are normally « produced by magnetic induction, and « measured by the voltage induced) has « been the subject of calculation by se- « veral Administrations. As far as pos- « sible, the factors having a bearing on « the subject and the effective current « values both for normal loads and for « short-circuits are being taken into « account.

« With direct current systems in par- « ticular, the calculated or measured « current gradients must be taken into « consideration. The calculations are « based on the formula recommended by « the C.C.I.T.T., and in the case of D.C., « at the moment of a short-circuit, on « the method of equivalent frequencies.

« The values of normal load and « short-circuit currents which would be « taken into account in this connection « are still a matter for discussion. There « is, however, a tendency to use, as a « basis, the actual load encountered in « practice.

« The soil resistivity factor which « plays an important part, is still ill- « defined and little known, and con- « tinues to be the subject of numerous « studies. Several parameters have the « effect of modifying the depth of cur- « rent penetration, which may falsify « the results obtained from the various « measuring methods in use.

« So far only few Administrations « have carried out systematic measure- « ments in this sphere, though it would « be highly desirable to proceed with « such measurements. Along high ten- « sion lines which could give rise to « inductive effects as well as along « railway lines scheduled for electrifica- « tion, it is desirable that measurements « should be carried out in accordance « with standardised methods, and with « the collaboration of the organisations « or Administrations interested in the « question.

« 4. The compensating factors which « influence the coupling effects vary « greatly.

« It some cases of A.C. electrifica- « tion the use of booster transformers, « with or without return conductors, re- « presents an additional compensating « factor — it may be necessary in the « case of high resistivity in the soil for « instance — as it reduces the flow of « current in the soil, at the cost of some « loss of energy in the traction circuit.

« The use of booster transformers is, « however, an additional cost on the « railway administration both in ca- « pital and annual charges, and they « should be considered only after inves- « tigating the possibility of modifying « the telecommunication circuits to « avoid recourse to this method. This « investigation, which should take into « account the probable development of « the telecommunications equipment, « can be made only in full agreement « with the Administration owning the « circuits, moreover, to obtain the most « economical and practical solution, col- « laboration between the two Adminis- « trations is essential.

« With D.C. electrification, certain « Administrations limit the number of « connections between the supporting « structures of the catenary and the rail « in order to reduce as much as pos- « sible the effects of traction current on

« two-rail track circuits, to give a warn-« ing of rail breakage and to reduce « corrosion of buried cables and metal-« lic conduits. For this purpose use « is made of spark gaps and also earth « wires. It is even possible completely « to eliminate connections to the rail « by continuous connection of the ca-« tenary supports.

« 5. It is important that account « should be taken of the screening « effects which arise from the metal-« work in the vicinity of the signalling « and telecommunication lines (metal-« lic conduits, long structures and, of « course, nearby sheaths and rails). The « question of screening effects is, how-« ever, extremely complex. These effects « are difficult to measure and, because « of the diversity of the relevant factors « as between one network and another, « it is difficult to interpret the results « of the practical tests which can be « carried out in this respect. The ques-« tion of determining the currents in « the conductors (modulus and phase « angle) must be faced.

« Some Administrations have carried « out, or are now carrying out measure-« ments in this sphere. So far, however, « the results obtained are few in num-« ber, and hardly conclusive.

« The volume of information supplied « on the screening factor of metallic « sheathing is small. The factor varies « with the frequency and with the satura-« tion condition of the metallic armour-« ing. It is desirable that Administra-« tions should carry out tests and « exchange information on the results.

« 6. Among the precautions taken « with a view to limiting the interference « phenomena in groups of overhead « telecommunication lines running along « electrified railway tracks, the following « measures can be named : elimination « of earth returns (this measure is, « moreover, recommended for all types « of circuit); placing the overhead lines « at the greatest practicable distance « from the tracks (though this factor « does not exert a preponderant in-« fluence); and mainly, the transposi-« tion of the conductors.

« It is important to arrange the lines « in accordance with a carefully studied « transposition scheme, designed to re-« duce the transposition intervals. But « even with perfectly regularly spaced « transpositions, various factors which « are unavoidable with the operation of « overhead lines are liable to introduce « unbalance conditions which are, more-« over, apt to vary.

« It would be desirable to carry out « supplementary research and studies on « the subject of the sensitivity coeffi-« cients and their variations.

« 7. For the installation of telecom-« munication and signalling cables along « electrified lines, buried cables are « generally preferred. Some Adminis-« trations, however, prefer cable con-« duits which ensure a better mechanical « protection of the cables and which, « moreover, contribute to the corrosion « protection of the cables in the case « of D.C. traction.

« The types of cables in use are still « generally provided with metallic ar-« mouring. They comprise a lead sheath « and, fairly often in the case of A.C. « electrification, an armouring of steel « tape or wire, although the latter type

« may be less efficient. Most of the « Administrations do not attach par- « ticular importance to the use of high « permeability armouring.

« The insulation of the conductors is « generally of the dry paper type for « telephone circuits, and of the impre- « gnated paper type for signalling cir- « cuits.

« The use of aluminium sheathing is « recommended by several Administra- « tions. In many cases, too, external « sheathing or coatings of insulating « materials are provided as a precaution « against corrosion.

« Little use is made, so far, of cables « without metal reinforcement where « the conductors are insulated with plas- « tics such as polythene or polyvinyl « chloride, or with natural rubber, and « where the sheath consists of polyvinyl « chloride or synthetic rubber.

« Except in the case of D.C. electri- « fication, the interruption of the con- « tinuity of the metallic sheathing and « armouring is not a widespread prac- « tice. In some cases where this is « done, the joints are not bridged by « capacitances.

« With D.C. current, earthing of « sheathing and armouring is not applied « except at one point, because of the « risk of corrosion. On the other hand, « with A.C. current there is nothing to « prevent earthing, as it increases the « screening effect of the sheaths and « armouring.

« 8. The precautions taken against « longitudinal induced voltages consist « in ensuring that these voltages, even « in the most favourable circumstances, « remain far below the breakdown test « voltage between conductors, and be- « tween conductors and sheaths. The « usual interruptions of the circuits at « the repeaters may be sufficient to re- « duce these voltages. Intermediate sec- « tionalisation by means of 1/1 isolat- « ing transformers may, however, re- « present a suitable solution. This « measure gives rise to complications « when verifying insulation of the con- « ductors, which can nevertheless be « done by different methods.

« The protection devices in use are « of conventional types : fuses, thermal « coils, overvoltage protection devices, « lightning arresters. The use of rec- « tifiers as a precaution against acoustic « shocks is also reported.

« 9. As a result of the precautions « taken, the disturbances experienced « are very small. In a few cases only « they have resulted in occasional break- « downs or unbalance conditions.

« Little information has been pro- « vided on the subject of the noise volt- « ages observed, but these values always « seem to be very small.

« 10. The value of the potential « above earth has not been generally « reported, but it does not in any case « exceed 120 V under normal working « conditions.

« For safety reasons, the staff are « often required to adhere to certain « rules when carrying out work on the « circuits; these rules take into account « the measures taken to reduce the volt- « ages to which the staff are liable to « be exposed. Special precautions may « become necessary if the cables are « placed close to a live catenary. Nor-

« mally, no special precautions are « taken in the case of signalling circuits, « because of the short length of the « latter.

« 11. The most effective way of « guarding against the danger of elec- « trolytic corrosion (which need only be « taken into account in the case of « D.C. electrifications) is to reduce the « electric resistance of the track as much « as possible, and to insulate the rails « as effectively as possible from the « soil. It is, however, necessary to en- « sure that the rail-earth potential does « not become dangerous to staff.

« Apart from resorting to cable con- « duits, special sheathing, special tape « wrapping, or interruptions in the elec- « tric continuity of the sheaths and « armouring (passive protection), the « cables are sometimes also protected « by polarized drainage or tapping « (active protection).

« 12. The problems associated with « the working of track circuits differ « for D.C. and A.C. electrifications, res- « pectively.

« The questions of unbalance pheno- « mena in track circuits in two lines « of insulated rails, and of the induc- « tion effects to be expected between a « track circuit and the contact wires « or rails of the adjacent track, would « seem to merit closer studies than has « been the case so far.

« The connection schemes are so « designed as to ensure safety even « under abnormal conditions prevailing « in the traction network.

« The impedance bonds used in the « track circuits are so designed that an « unbalance not exceeding a certain « value (which, incidentally, varies as « between one Administration and « another) between the two windings « does not disturb the working of these « circuits. All the receiver apparatus « used in the track circuits must be « designed to work with particularly « high selectivity.

« It is considered that the systems in « use do not call for special precautions « as regards transient phenomena.

« Overvoltage protection, where this « is deemed necessary, is obtained either « by means of spark gaps or discharge « gaps, or by means of a judicious « adaptation of the equipment (transfor- « mers becoming saturated when the « currents become too high).

« 13. *With D.C. electrification,* the « following types of track circuits are « used :

« — A.C. feed at industrial frequency « (e.g. 25, 42, 50, 60) or, in some spe- « cial cases 83.3 c/s, using induction « relays with two de-phased elements or, « sometimes, rectifier relays;

« — A.C. feed at audio, or higher « frequencies up to 20 000 c/s or with « high tension impulses, obtained by « means of electronic apparatus, using « appropriate D.C. relays;

« — track circuits with coded cur- « rents, using coding and decoding « relays;

« — sometimes, for very short track « circuits, D.C. feed.

« Where single-rail track circuits are « used, a length limitation must be « accepted. Certain Administrations

« take further precautions in order to « protect the equipment and to ensure « the proper working of the installations. « Other Administrations regard these « precautions as unnecessary as they do « not enhance safety.

« With two-element induction relays, « the effects of the harmonics of the « rectified current need not be feared. « However, the choice of frequency « must take into account the special « condition where harmonics of the « same frequency can be produced. « With rectifier relays, the length of the « track circuits must be limited.

« The use of protective devices (fuses « or discharge gaps) varies greatly as « between one Administration and « another.

« 14. *With A.C. electrifications,* the « following types of track circuits are « used :

« — A.C. feed at 42, 75 and 100 c/s « for 16 2/3 c/s traction, and at 83.3 c/s « for 50 c/s traction, using induction « relays with two de-phased elements « supplied from two separate phases.

« — A.C. feed at frequencies from « audio up to 20 000 c/s or with high- « tension impulses obtained by means of « electronic apparatus, using appropriate « D.C. relays;

« — track circuits with coded cur- « rents, using coding and decoding « relays.

« — D.C. feed, using D.C. relays « with special characteristic (e.g. short- « circuit rings or windings), series-con- « nected with inductive elements offer- « ing a high impedance to the traction « current.

« The frequencies of the supply volt- « ages are so chosen as to keep away « from the frequency of the traction « currents and its most important har- « monics.

« 15. The measures taken to avoid « disturbances liable to arise from inter- « ference of the traction current with « signalling circuits other than track « circuits consist in a judicious choice « of the type and voltage of the feed, « and of the type of equipment.

« In particular when D.C. relays are « used, care must be taken to see that « they are not affected by the induced « voltages to which they may be sub- « jected.

« Two-wire circuits are preferred, « without earth conection, and generally « with double-pole circuit breaking.

« 16. As far as the telecommunica- « tion lines are concerned, close adhe- « rance to the Regulations and the « « Recommendations » of C.C.I.T.T. « ensures that both the danger due to « induction effects and the psophome- « tric voltages in the circuits will be « limited to values which allow normal « working. It is, however, always « necessary to compensate with care the « umbalance capacities of the lines, but « the techniques used with cables are, « in this respect, well known.

« Carrier equipments, which are very « much less sensitive to induction, are « moreover being increasingly used for « long distance telephone circuits. »

SECTION III : Working.

QUESTION 3.

Transport on railway wagons of road-lorries and trailers loaded with goods.

Questions arising from this mode of transport :

— The role of the road-hauliers;

— Tariffs to be applied;

— Characteristics of the railway rolling stock to be employed;

— Installations for loading and unloading;

— Use of single wagons, or of sets of wagons, or of complete trains for this kind of transport.

Results already obtained and possibilities of extending this mode of transport.

SUMMARIES.

The advantage of carrying road vehicles loaded with goods by rail.

« 1. The Administrations in general « consider that the transport by rail of « road vehicles loaded with goods is of « great interest to the railways.

« The Administrations operating to « this formula or who have made trials « of it are generally in favour of « extending it.

« The essential motives for their in- « terest in this formula are :—

« *a*) it is an excellent solution of the « door to door problem;

« *b*) the technical co-ordination of « rail and road brings back long-distance « traffic to the railway and relieves con- « gestion on the roads.

Organisation of the service, part to be played by the road transport undertakings.

« 2. In carrying out such services, « two formulae have been used :

« *a*) service assured from one end to « the other under the responsibility of « the railway;

« *b*) service assured by the road trans- « port undertaking, which hands over the « vehicle to the railway for the journey « by rail.

« The first formula has the advantage « of giving the railway complete control « over the traffic, and assuring direct « contact with the clients, with the pos- « sibility of encouraging them to the « greatest possible extent to make use of « the most advantageous method : wa- « gon or the rail-road formula. It is « valuable in particular in those coun- « tries where the railway is authorised « to run road services.

« The second formula leaves control « of the traffic in the hands of the road « transport undertakings for whom the « railway merely provides the rail trans- « port. Above all, it has the advantage « in those countries where public road « transport undertakings are licensed on « a quota basis, of diverting to the rail- « ways part of the road transport poten- « tial in the case of transport carried out « for a third party which would continue

« to go by road if the railway would only « carry out transport over the whole run; « it also attracts private transport which, « in the case of the first formula, would « not be entrusted to the railway.

« The possible utilisation of one or « other of these two formulae is there- « fore a function of the ruling system « governing the railways and the roads « in each country, as well as of the pos- « sibilities of collaboration between the « railway and the road transport under- « takings, and the advantage of such col- « laboration for the railway.

Technical questions.

« 3. The chief formulae which have « been used or tried are :

« *a*) transporting an ordinary road « vehicle on a standard type wagon;

« *b*) transporting a special type of « road vehicle, with or without its run- « ning gear, on a standard type wagon;

« *c*) transporting a standard type of « road vehicle on a special type of « wagon;

« *d*) transporting a special type of « road vehicle, with or without its run- « ning gear, on a special type of wagon;

« *e*) combined rail-road vehicle.

« 4. The first formula is obviously the « most satisfactory. It is widely used in « North America, but is very often not « possible in Europe owing to the di- « mensions of the railway loading gauge.

« 5. The fifth formula is attractive, « but raises delicate problems owing to « the difficulty of reconciling the road « and railway techniques and regulations « (weight, dimensions).

« 6. The three other formulae each « have their advantages and drawbacks. « Various considerations effect the « choice to be made between them.

« The loading and unloading of the « road vehicle on the wagon must be « as rapid as possible, so as to speed « up the transport of the goods.

« The amount and cost of the capital « invested in the stock tends to limit « specialisation of both road and railway « stock.

« The cost of the transport leads to « endeavour to have as low as possible « a dead weight for both road vehicles « and wagons, and the greatest possible « load and useful volume, taking into « account technical exigencies (loading « gauge, weight on rail, weight on road). « This generally leads to a preference « being given to road semi-trailers (in « conjunction with automatic centering « on the wagon), the use of which is « being extended on the roads of Europe, « whilst they are almost exclusively used « in America for long distance traffic.

« 7. It is therefore permissible to « think that, in those countries where « the formula of agreements with the « road transport undertakings is adopted « (formula *b* of point 2), it is best to « adopt a system allowing of the use of « a standard type of road semi-trailer « which will only require very slight « modification. This is the third for- « mula which is adopted in the United « States (Clejan), Germany (low-loader « wagon) and France (S.E.G.I. low- « loader wagons and Kangaroo wagons).

« In addition, the use of semi trailers « has the advantage of avoiding trans- « porting the tractor and the road driver, « who remain at the operating centre.

Loading and unloading installations.

« 8. The loading and unloading instal- « lations depend upon the rail-road sys- « tem selected.

« Such installations must allow of a « rapid change-over from rail to road « and vice versa, which at the present « time is only assured by self-contained « transfer systems. In this connection, « the use of some system of guiding the « semi-trailers when loading them on the « wagons considerably facilitates obtain- « ing such a result.

« The capital investment must be « limited to the essential minimum « needed to enable all the stations where « it is desirable to load and unload road « vehicles to be so equipped.

« The use of mobile loading ramps « which can easily be moved about and « used with the minimum of alteration « to the station would appear a solution « to be recommended whenever it is « technically possible.

Carrying out the transport (single wagons or complete trains).

« 9. Sending forward by complete « train has great advantages by giving a « shorter transport time and lowering the « cost for the railway.

« This is the method to be recom- « mended whenever the traffic is suffi- « cient; it involves limiting the number « of stations where such traffic can be « accepted, with the corollary that the « terminal road hauls will be increased.

« 10. Sending forward by single wagon « or groups of wagons meets the case « when the traffic is insufficient to form « complete trains; it allows a great many « stations to be served and limits the « terminal road hauls to short distances; « the wagons must be sent on by fast « goods trains in order to assure that « the transport time remains competi- « tive.

Terminal road runs.

« 11. These services are assured either « by the railway or by road hauliers, « according to the operating formula « adopted. Certain Administrations limit « the length of the terminal road runs; « such restrictions may also be the result « of the road traffic regulations in force « in the country in question.

« In general, the drivers do not travel « with the road semi-trailers carried by « rail, so that it is an advantage to pro- « vide road transport organisations at the « terminal stations. Such organisations « can be set up either by the railway or « by the road transport undertakings.

Tariffs.

« 12. When the railway works the « traffic from end to end, it charges « clients directly a transport rate which « may be either a door to door tariff « (for example the road tariff if there « is one) or the railway rate plus a « haulage charge.

« 13. If the railway is merely provid- « ing transport for a road transport

« undertaking, it has no direct contact « with clients and charges the road firm « a rate for the railway journey. In view « of the special features of this traffic, « and according to the tariff formula « adopted by most of the Administra- « tions, who have experience of this kind « of transport, it is recommended to « establish the rate independently of the « kind of goods and base it on the road « costs, taking into account the distance « of the transport, the gross weight of the « vehicle and the competitive position on « the route concerned. The applied « tariff, of course, has to assure a rea- « sonable profitability of the transport « and to avoid any transfer of existing « railway traffic.

« The tariffs should be profitable to « the road transport undertakings who « regularly send vehicles over a given « journey and thus allow of a traffic « programme being established.

Future prospects.

« 14. In North America, where the « very large railway loading gauge faci- « litates solving the technical problems « of rail-road traffic, this kind of traffic « is already very extensive.

« The experience of European rail- « ways (D.B. and S.N.C.F.), who have « already perfected certain solutions to « the technical problems raised by a « smaller loading gauge, shows that there « is also a potential for such traffic in « Europe.

« 15. In any case, we should not « expect to get such traffic to the rail- « way in the case of short rail hauls. « The minimum distance to be taken « into account would generally be from « about 300 to 400 km.

« 16. As a result, in the case of « regions which are parcelled up poli- « tically as they are in Western Europe, « full expansion of such traffic can only « be obtained with formulae for inter- « national transport.

« 17. Owing to the same political « divisions, there is a risk of different « solutions coming out for the technical « problems raised by the small loading « gauge. The heterogeneous nature of « the various solutions may well retard « the growth of the traffic; to encourage « such growth it would be desirable for « the railways to co-ordinate their efforts « and adopt a common solution, or if « this is not possible at least only a very « limited number of technical formulae « which will allow of traffic exchanges « between all the countries concerned « and the use of the same terminal « installations.

« 18. For the rail-road formula to « succeed, it is essential for the railway « to assure, in an atmosphere of mutual « confidence, as close a collaboration as « possible with the road transport under- « takings. Such collaboration may take « very varied forms, such as contracts « made between the railway and the « road transport undertakings, organisa- « tions in which the railway Administra- « tions and the road haulage firms share « in working the combined rail-road « transport.

« 19. The fact that the rail-road « transport formula is favourable for the « general economy justifies on the part « of the Governments the setting up of « equitable customs and fiscal regulation « measures suitable to facilitate its deve- « lopment on the national and interna- « tional plane. »

SECTION IV : General.

QUESTION 4.

What steps can be taken to develop and maintain co-operation between management and staff to improve productivity ?

What scope is there for work study and incentive schemes ?

SUMMARIES.

Part I.

« 1. It is generally agreed that of the « factors contributing to increased pro- « ductivity, the human factor is the most « important.

« *Enlightened leadership is all-impor-* « *tant* because experience shows that a « passive attitude on the part of the « staff can not only retard but even « prevent any increase in productivity « which is otherwise technically possible.

« 2. There must be complete confi- « dence between employees and mana- « gement. The Administrations endea- « vour to create an atmosphere of « confidence by :

« — explaining to their staff, the « meaning of productivity, the reasons « for increasing and the means to « achieve it;

« — minimizing any disagreeable con- « sequences which may arise temporarily « from the changes necessary to increas- « ed productivity;

« — having their staff participating « in one way or another, in the result- « ing benefit.

« 3. There should be consultation at « all levels, particularly where changes « affecting individuals are contemplated.

« *Productivity councils* on which the « highest levels of management and *the* « *staff* are represented, are invaluable « in maintaining a good atmosphere and « keeping *the staff informed at an early* « *stage* of the management proposals.

« The success of these councils is « enhanced by the setting up of Com- « mittees at lower levels.

« 4. A feeling of security is essential. « In general, there should be no dismis- « sals due to increased productivity. « Any reduction in the establishment of « staff should be met by internal « wastage, transfers and the curtailment « of recruitment, even though planned « progress may be temporarily retarded.

« Whenever desirable and possible, a « change of job and any necessary « re-training should be arranged to « avoid transfer to another centre and « should such transfer prove inevitable,

« provision should be made within the « framework of regulations relating to « the transfer of personnel.

« 5. A valuable contribution to « increased productivity is for mana- « gement to provide and maintain well- « conceived training schemes for all « grades of staff.

« Working conditions must be of a « good standard. Staff will always « respond better if due regard is paid to « their personal welfare.

« 6. Whilst the provision of general « productivity indices is often necessary, « it is very advantageous that the pro- « ductivity of small units such as groups « of staff at local level should be clearly « expressed.

« 7. There should be reasonable pro- « motional prospects and the promotion « schemes should be clearly defined.

« 8. Suggestion schemes are valuable « for the submission of new ideas by « members of the staff.

« 9. The exchange of information in « regard to productivity should be « encouraged. Small teams to visit pro- « jects of common interest would be « advantageous.

Part II.

« 10. There is scope for Work Study « in every activity associated with a « railway undertaking.

« 11. Work Study provides both a « qualitative and a quantitative assess- « ment of the utilisation of equipment « and staff in terms which can be « universally understood and compared.

« 12. In the introduction of Work « Study the full co-operation of the « staff and their representatives should « be encouraged and sought.

« 13. It is essential that Work Study « personnel should be well trained. If « investigations are carried out by « inexperienced staff, the benefits of « Work Study will never be realised.

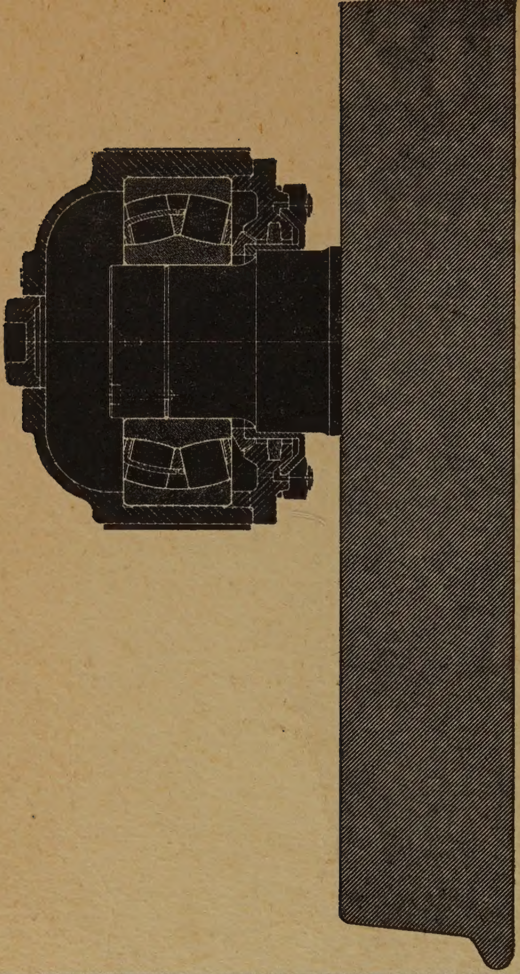
« It is clear that a sufficient number « of competent personnel be trained in « Work Study techniques if tangible « progress is to be made.

« 14. Providing method study and « work measurement are efficiently « carried out incentive bonus schemes « are a very good means of improving « individual performance : the bonus « should be substantial if the schemes « are to be effective, whilst safeguarding « the standard of work performed.

« Individual or small group incentive « schemes such as may be applied in « marshalling yards are more commonly « used and this basis in general seems « the most desirable.

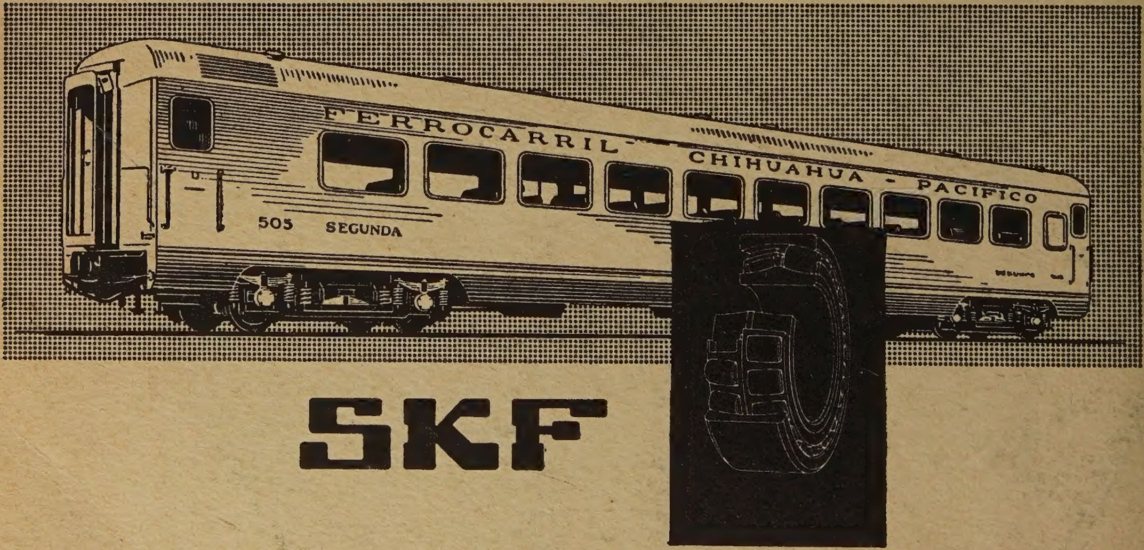
« 15. Whilst the provision of finan- « cial incentives is often necessary. « good working conditions and good « management in creating the proper « spirit of understanding are of very « great importance.

« 16. As a general conclusion it is « accepted that the introduction and « widest extension of Work Study « schemes is in the interest of all rail- « way undertakings and their employees. « They can prove of very great benefit « in meeting the special difficulties « which confront railways in all parts « of the world. »



Mexico also chooses SKF roller bearing axleboxes

The illustration shows one of 150 passenger coaches of all-welded construction that are in use on the National Railways of Mexico. These coaches, which are built to AAR standards, have been in service for some years. They weigh 53 tons and all bogies are fitted with SKF roller bearing axleboxes.



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